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BACTERIOLOGY.

A MANUAL FOR STUDENTS AND PRACTITIONERS.

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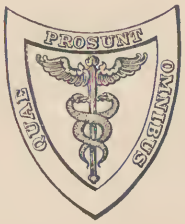

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PREFACE.

THE general tendency of modern medicine is to divide the science into separate and distinct special branches. The literature of each specialty is so voluminous and is increasing at such a rate that a thorough treatment of even one of these subjects would expand the size of this book far beyond the limits which have been assigned.

Therefore in compiling this little work, in which three specialties are discussed, the effort has been made simply to present the *main* facts of each subject in a concise manner to save time both for the student and the busy practitioner. It is not intended, however, to replace a more extended reading if one's time permits.

In the preparation of this volume I am indebted to the works of Delafield, Prudden, Schafer, Klein, Zeigler and Fraenkel, which have been freely drawn upon.

BENNETT S. BEACH, M. D.

210 West Thirty-fourth st.,
New York,
October, 1892.

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HISTOLOGY.

PATHOLOGY.

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HISTOLOGY.

Of what does Histology treat?

For our present purpose histology may be regarded as treating of the *minute structures of tissues and organs* of man.

What are the structural elements of the body?

Cells, fibres, and intercellular substanee.

From what do these elements originate?

From the development of a single nucleated eell or *ovum.*

CELLS.

Describe the human ovum.

It is a small spherical vesicle of about $\frac{1}{125}$ inch (2 mm.) in diameter, with a covering called the *Zona pellucida* or *Zona radiata.* Within the covering is a spherical mass called the *Germinal vesicle.* Within this is a smaller body called the *Germinal spot.*

Considering the ovum as a typical cell, what would its different parts be called?

The *Zona pellucida* would correspond to the *cell-wall.*
The *Vitellus* would correspond to the *cell-body.*
The *Germinal vesicle* would correspond to the *nucleus.*
The *Germinal spot* would correspond to the *nucleolus.*

What parts corresponding to parts of the ovum or primary cell are always present in animal cells?

The *cell-body* and the *nucleus,* whieh is a minute vesieular strueture contained in the eell-body.

What parts are usually absent?

Cell-wall and *nucleolus.* Very few animal cells having either strueture.

What is the structure of the cell-body?

It is made up of an albuminoid material called *protoplasm.* Under the microscope this may appear elear or homogeneous, finely granular, or even reticulated.

What vital phenomena are common to all protoplasm?

The absorption of and combination with *oxygen*, the production of *carbon dioxide* and other products of oxidation.

What are the results of these changes?

Heat is produced and cells perform their individual functions.

How is the vitality of protoplasm sustained?

Living protoplasm possesses the chemical property of being able to assimilate and convert into its own substance non-living proteid material.

Describe the power of motion possessed by living protoplasm.

The protoplasm of some cells, notably that of white bloodcells, shows changes of form.

This change is called *amœboid motion* and is accomplished by a budding out of the protoplasm in one or more places. These protrusions may be withdrawn, or the mass of protoplasm may flow along one particular elongation, and so transfer its bulk to that particular spot.

Describe and give structure of the nucleus.

It is a small vesicular body embedded in cell protoplasm, and is surrounded by a homogeneous envelope called the *nuclear membrane*. This encloses the nuclear contents.

What are the nuclear contents?

They are of two kinds—the *formed*, made up of threads or fibres, called the *intra-nuclear network*, and the *amorphous*, which is supposed to be of a fluid nature.

What is the function of the nucleus?

It is concerned in the reproduction and division of cells.

What is the nucleolus?

It is a small shining globule or vesicle frequently found in nuclei. Of its nature and significance we have no definite knowledge.

What is cell-wall?

It is a limiting membrane possessed by a few animal cells and by all vegetable cells. It seems to be made up of altered cell-protoplasm.

In what two ways do cells multiply?

By *direct* and *indirect* division of nuclei.

Describe the direct method of division.

The nucleus divides into two parts by a simple process of constriction. The cell-body divides in the same way, each part of the cell-body appropriating a nucleus to itself.

Describe indirect cell division or karyokinesis.

The intranuclear network becomes converted into a convoluted thread, changing to a rosette or wreath, then forming a star or *aster*, the centre of which is the centre of the nucleus.

The nucleus now becomes oval. The rays of the aster collect around points at the ends or poles of the nucleus, and form the *diaster*.

The centre of the nucleus is now called the *equator*. Next it divides through the equator, and by a reversal of the process each part becomes a *daughter nucleus*. The protoplasm changes and becomes divided at about the same time that the nucleus separates.

What are the vital properties of all cells?

Nutrition, *growth*, *function*, and *reproduction*.

CLASSIFICATION OF TISSUES.

How are all embryonic cells formed?

By division and subdivision of the ovum.

After a large number of cells are formed how do they arrange themselves?

Into a membrane called the *blastoderm*.

Describe it.

It is composed of two portions. First, the *Archiblast*, which is divided into three layers, the *Epiblast* or outer layer, the *Mesoblast* or middle layer, and the *Hypoblast* or inner layer. The other portion of the blastoderm is called the *Parablast* and fills up the interstices of the mesoblast. Its origin is uncertain.

Of what elementary tissues is the human body composed?

The *Epithelial Tissues*.
The *Connective Tissues*.
The *Muscular Tissues*.
The *Nervous Tissues*.

From what layers of the blastoderm are these different tissues produced?

Of the archiblastic layers the epiblast gives origin to the epithelium of skin and adnexa, to the epithelium of the terminal portions of

the alimentary canal, to the neuroglia and nervous system. The mesoblast furnishes material for the genito-urinary organs and for voluntary and involuntary muscle. From the hypo-blast is developed the epithelium of: the respiratory, the genito-urinary, and digestive systems, and the various glands and passages in connection with them. From the parablast comes the material for the formation of the connective tissue, including cartilage, bone and fat, lymphatic vessels and tissues, bloodcells and bloodvessels, and the true endothelial cells.

EPITHELIAL TISSUES.

What is the general structure of epithelial tissues?

It is a tissue composed entirely of cells, with a comparatively small amount of intercellular substance. It usually takes the form of a membrane covering free surfaces.

Give the most important surfaces covered with epithelial tissue.

Surface of the skin.
Surface of mucous membranes.
Surface lining the ventricles of the brain and spinal canal.
Free surfaces of serous membranes.
In organs of special sense.

To what cells is the name endothelium applied?

To certain delicate or modified epithelial cells lining serous cavities and bloodvessels.

What is the classification of epithelial tissue?

Simple, *stratified*, and *transitional.*

What is the structure of simple epithelial tissue?

It is composed of a single layer of cells.

Give its varieties.

Pavement, *columnar*, *glandular*, and *ciliated epithelial tissue.*

Describe pavement epithelium.

This is made up of a single layer of polygonal-shaped cells, placed together *edge to edge*, like stones in a mosaic, and united by a small amount of intercellular cement substance.

Describe columnar epithelium.

It is made up of cubical or cylindrical-shaped cells *set on end*, in profile looking like a close palisade. When seen from above they appear polygonal and resemble pavement epithelium.

Describe glandular epithelium.

Glandular epithelial cells in form are columnar, cubical, polyhedral, or spheroidal in shape, and are usually set around a tubular or saccular cavity upon a basement membrane.

Describe ciliated epithelium.

These varieties are usually cylindrical in shape, and on their free borders bear little hair-like processes, which in life have a lashing or vibrating motion.

What is the shape and arrangement of cells in stratified epithelium?

The deepest layer is columnar and the superficial layer scaly. In the intermediate layer of cells next the deepest layer, the cells are round, but gradually become flattened as we approach the superficial layer. The cells of this last layer have lost their nuclei and become horny in structure.

Where is the best example of transitional epithelium found?

In the lining wall of the bladder.

What are the characteristics of this form of epithelial tissue?

The superficial layer of cells is either flattened or cubical in shape, the cells being smooth on their free surface and pitted on their opposite side. In the next layer the cells are pear shaped, the large end fitting into the depressions on the under surfaces of the superficial cells, and the small end set upon the subjacent connective tissue. Filling these spaces between these tapering cells is a third layer of irregular-shaped cells.

CONNECTIVE TISSUES.

Of what elements is connective tissue composed?

Fibres, *intercellular substance*, *cells*, *vessels*, and *nerves*.

Give the principal varieties of the connective tissues?

Fibrous,	Adipose,	Cartilage,
Embryonal,	Reticular,	Bone,
Mucous or mucoid,	Lymphoid,	Elements of blood and lymph.

Into what subdivisions are the fibrous connective tissues divided?

Areolar, *white fibrous*, and *yellow elastic tissue*.

What are the physical characteristics of white fibrous tissue?

It is white with a shiny or pearly lustre.

It is exceedingly tough but pliant.

It is almost entirely wanting in extensibility, and is therefore non-elastic.

What structures are composed almost entirely of white fibrous tissue?

Tendons, ligaments, periosteum of bone, fascia, and all tissue in which *great strength* is needed *without extensibility.*

Of what is white fibrous tissue composed?

Of bundles of white fibres which in turn are made up of finer fibres or fibrillæ. The fibres and fibrillæ are held together by an intercellular cement substance These fibres usually run parallel, and although they may interlace they never branch. Here and there between the fibres are found flattened connective tissue cells, called tendon cells.

Describe the physical characteristics of yellow elastic tissue.

As its name indicates it is yellow in color and is very elastic, readily contracting after having been extended. It is not so strong as the white fibrous tissue, breaking when over-extended.

Where is this tissue found in the human body most abundantly?

In the *ligamenta subflava, hyoid ligaments, vocal cords,* and in the *walls of the bloodvessels.*

What is the microscopic structure of yellow elastic tissue?

It is composed of large, clear fibres which branch, giving a sort of reticulated appearance when partly separated.

Give the differential points between white fibres and yellow elastic fibres.

White fibres are made up of finer fibrillæ which usually run parallel; they may interlace, but they never branch. *Yellow elastic fibres* are coarse, highly refractive, they do branch, and when torn apart have a tendency to curl up at the ends.

What are the macroscopical appearances of areolar tissue?

It is soft and fleecy-looking, but having considerable strength and elasticity, and when stretched between the fingers it seems to be composed of a multitude of clear-shining fibres intermixed with fine films, or lamellæ.

Where is areolar tissue found in the body?

It is the most widely distributed tissue. Starting under the skin where it is abundant it may be traced under serous and mucous membranes, along bloodvessels, and nerves, around and between

muscle-fibres and bundles, and gives support to all the organs of the body.

How is it made up microscopically .

Of a homogeneous ground substance in which white and yellow elastic fibres cross and interlace in every direction. The density and strength of a particular piece of the tissue depends upon the number of these fibres and the closeness of their arrangement. Between the fibres in the ground substance we find cells of different shapes and sizes, the connective tissue cells proper.

What is the ground substance of connective tissue ?

The ground substance or intercellular substance is composed of a soft, homogeneous material occurring between the cells and in which the fibres lie. It serves as a cement substance to hold the cells and fibres together. When the fibrous elements are very abundant the ground substance is obscured.

Name the varieties of cells in connective tissue ?

Flattened or *lamellar*, *granular*, and *vacuolated* or *plasma cells*.

Describe the flattened or lamellar cells ?

Some are flat and are applied to the surfaces of bundles of white fibres, others are between these bundles and have peculiar wing-like processes thrust out between bundles of fibres.

Describe granular cells ?

They are corpuscles containing granules in the cell-body and are found especially abundant near bloodvessels.

Describe the vacuolated or plasma cells ?

They contain numerous vacuoles or small holes in the cell-protoplasm, thus differing from the two preceding types. These vacuoles are filled with a fluid resembling lymph, or blood plasma.

What is the structure of embryonal connective tissue ?

It is composed of small round cells, having no definite arrangement, and lying in a homogeneous intercellular substance. In this intercellular substance are numerous fine fibres or fibrillæ.

How is this tissue formed ?

The mesoblastic cells, which are to form connective tissue, are loosely packed together with an albuminous fluid between them ; later this fluid becomes more consistent, and little fibrils are formed in it.

What is mucoid tissue?

It is an embryonal tissue having a large amount of intercellular substance, which contains mucin. This intercellular substance contains numerous fibres and a few scattered fusiform and branching cells.

Give an example of this form of tissue?

The umbilical cord. In this the intercellular substance is very abundant, and has received the name of *Wharton's jelly.*

What is the microscopical appearance of adipose tissue?

It seems to be made up of numerous small vesicles filled with a fatty or oily substance. These vesicles are found most often lodged in the meshes of areolar tissue.

Where is adipose tissue found in the human body?

It is widely distributed. It is very abundant in subcutaneous areolar tissue. It is found about the kidney, heart and around the joints. Also in the mesentery and omentum and in marrow of bones.

Where is adipose tissue never found normally?

It is not found in the lungs except near their roots, and never in the cranium, nor in the subcutaneous areolar tissue of the eyelids and penis.

What are other features concerning adipose tissue?

It is well supplied with bloodvessels with which the lymphatic vessels are in close relation. No nerves terminate in it, although nerves supplying other parts pass through it.

How is adipose tissue developed?

At about the fourteenth week of intra-uterine life minute droplets of fat are deposited in certain connective tissue cells. These droplets, gradually increasing in size, finally coalesce, forming a single large drop. This drop, increasing in size, pushes the cell-protoplasm out to form the wall of the fat-vesicle. The nucleus of the connective tissue cell is also pushed out to the periphery of the vesicle, and may finally, through pressure, atrophy and disappear.

What is the structure of reticular tissue?

It is composed of a fine network or reticulum resembling that in white fibrous connective tissue. The spaces between the fibres communicate one with another and are filled with fluid instead of intercellular substance.

What connective tissue cells are found in this kind of tissue?

The *flattened* or *lamellar cells*. They are very thin and are wrapped around the fibres, making the structure look as though it were composed of branching cells with anastomosing branches.

Where is reticular tissue best seen?

In lymphatic glands; but as the interstices in the network of fibres are filled with round or lymphoid cells, the reticular structure is so covered that it cannot be seen unless the round cells are washed out.

Describe lymphoid tissue.

It is a reticular tissue having its interstices filled with lymphoid cells.

What is the appearance of lymphoid cells?

They are small round cells in which the nucleus is very large, and the amount of protoplasm relatively small.

In what parts is lymphatic tissue found?

Lymphatic glands, tonsils, and the solitary and agminated follicles in the small intestine.

What is the macroscopical appearance of cartilage?

It may be of a pearly white or of a yellowish color, it is firm and dense, and yields to pressure or torsion, resuming its former shape when the constraining force is removed.

What is the perichondrium?

It is a moderately vascular fibrous membrane which covers all cartilages except those at the joints.

What are the varieties of cartilage?

Hyaline, *yellow elastic*, and *white fibrocartilage*.

Into what classes may hyaline cartilage be divided?

Temporary and *permanent*.

Where is temporary cartilage found?

The skeleton of the embryo is made up in great part of hyaline cartilage, which later becomes ossified and forms true bone.

What are some of the permanent cartilages?

Costal cartilage, *articular cartilage* on the articular surfaces of bones, and the *tracheal cartilages* in the trachea.

What is the structure of hyaline cartilage?

The bulk of it is made up of a homogeneous material or matrix, which is perfectly structureless. In this are rounded or oval cell-bodies scattered irregularly. These cells have a round nucleus and may have more than one.

The cells are contained in cavities in the matrix, which cavities they entirely fill in the fresh state.

What are common modifications of the structure of hyaline cartilages?

In the costal and articular cartilages the cells are arranged in groups and the matrix sometimes appears granular. Near the margin of attachment between articular cartilage and connective tissue, the cartilage cells are sometimes branched.

Where is yellow elastic cartilage found in the human body?

In the *epiglottis*, the *cartilages of the ear*, and *Eustachian tube*, and in the *cornicula of the larynx*.

What is its microscopical structure?

It differs from hyaline cartilage in that the matrix is everywhere traversed by fibres of yellow elastic tissue. Intermixed with these are small plates of hyaline material, each containing a single cartilage cell.

Where is white fibrocartilage usually found?

In the marginal cartilages by which the shoulder and hip joints are deepened. In the inter-articular cartilages of the spinal column, knee joint, and joint of lower jaw.

What is the structure of this form of cartilage?

It is made up of white fibrous tissue just as tendon is. Between the fibres are cartilage cells singly or in groups, each embedded in a small plate of hyaline material.

Are there any vessels or nerves in cartilage?

There are no nerves, and in articular cartilages there are no blood-vessels. In large masses of cartilage are canals here and there in which bloodvessels run. These canals are very few in number.

What are the principal parts of bone?

Its *covering* or *periosteum*.

The *hard* or *earthy part*, and the *marrow*.

Name the two general varieties of the hard part of bone.

Compact bone and *cancellous* or *spongy* bone.

Where is compact bone found?

In the walls of the long bones, and in the outer and inner plates of flat bones.

Where is cancellous bone found?

In the heads of the long bones and between the plates of the flat bones.

Upon what does the difference between these two classes of bone depend?

It depends upon the difference in the *amount* of *earthy matter*. In compact bone the earthy matter is *abundant* and the spaces small; in cancellous bone the earthy matter is *scant* in amount and the spaces are large.

What are the spaces in compact bone called?

Haversian canals.

What is the structure of compact bone?

It is made up of an intercellular substance; in this basement substance are little spaces containing delicate branching cells. The intercellular or basement substance is impregnated with salts of lime, which gives the bone its hardness.

What are these spaces called?

Lacunæ.

What are canaliculi?

They are small delicate canals connecting lacunæ one with another, and also with the Haversian canals.

What is an Haversian system?

When an Haversian canal is cut transversely, the hard substance of bone will be seen arranged around it in concentric rings or lamellæ. Between these lamellæ will be seen little spaces or lacunæ connected by canaliculi. Each lacuna contains a delicate branching cell called a bone-cell. The whole taken together is an Haversian system.

How is the shaft of a long bone made up?

Of multitudes of these Haversian systems, the spaces between which are filled by irregularly arranged lamellæ of bone.

What is the structure of cancellous bone?

This is composed of thin plates and interlacing spiculæ of bone, which in turn are made up of several lamellæ of bone superimposed one upon the other in several layers.

After bone has been decalcified what is the structure of the part remaining?

While the bone retains its original form, the lamellæ on being examined microscopically seem to be made up of an exceedingly fine network of decussating fibres, and to be perforated by minute holes.

What are these holes supposed to form?

When the lamellæ are placed together with these openings in apposition it is supposed that they form canaliculi.

What are Sharpey's fibres?

If from a decalcified flat bone you tease off a lamella, often there will be seen projecting from it small tapering fibres, which served to pin it to its adjacent lamella. They are never found in the concentric lamellæ of Haversian systems.

What is periosteum?

It is a fibrous membrane which covers the external surfaces of bones.

How many layers is it composed of?

Two—an *outer* and an *inner* layer.

What is the structure of the outer layer?

It is made up of *white fibres*, and contains numerous bloodvessels, lymphatic vessels and fine nerve fibres; occasionally fat-cells are found in this layer.

What is the structure of the inner layer?

It is composed of *elastic tissue.*

What is the office of the periosteum?

To support vessels for the nutriment of bone. When it is destroyed the bone dies.

Where is marrow found?

In the medullary cavity of long bones, in the spaces in spongy bone and in some Haversian canals.

What are the varieties of marrow?

From its color it may be divided into two varieties, *yellow* and *red.*

Give the structure of yellow marrow.

It is composed almost completely of fat-cells.

What is the structure of red marrow?

Fat-cells, round cells resembling lymphoid cells, called marrow cells, and large granular cells having several nuclei, these last are called

myeloplaxes or giant cells. In the marrow of developing bone are seen oval or polyhedral granular cells of good size with a single large nucleus, these are the *osteoblasts.*

In what two general ways is bone developed?

By *intra-cartilaginous* and *intra-membranous ossification.*

What bone may be taken as an example of intra-membranous ossification?

The parietal bone.

What are the relations of the parietal bone with adjacent parts in the embryo?

Without, *integument;* within, *dura mater;* while between these two layers there is found an intermediate layer in which ossification begins.

What is the appearance of this commencing ossification?

There is a network of fibres similar to white fibres. At the centre of this mass of fibres is seen a deposit of lime salts in the form of spiculæ or bars. These spiculæ interlace, and the spaces between them gradually become filled up with the lime salts. This process continues to spread until the parietal meets the other cranial bones.

How are long bones produced?

By cartilaginous ossification.

What is the first step toward bony formation?

There is first what might be termed a pattern of the bone to be formed made up of hyaline cartilage.

How does the ossification begin?

At the centre of the bone the cartilage cells begin to swell. The *matrix* is infiltrated with a granular precipitate of lime salt. The cartilage cells above and below the point of beginning ossification are arranged in rows in the calcified matrix. The spaces occupied by them are called primary areolæ.

At this time what change is going on outside the cartilage underneath the periosteum?

A layer of bony tissue is being formed by the osteoblasts, which are large nucleated cells contained in the periosteum.

What is the next step in the process?

There is an irruption of sub-periosteal tissue, and of osteoblasts into the middle of the cartilage. Here the osteoblastic cells absorb the calcareous deposit between the primary areolæ forming larger, or

medullary spaces, or secondary areolæ. These spaces are occupied by embryonic marrow and osteoblasts. Around these spaces bony material is finally deposited to form the true bone.

What becomes of the cartilage cells in the process of ossification?

There are two theories, one being that they are destroyed and disappear, the other that they are changed to form the osteoblasts.

What does the absorption and the final precipitation of the bony material in the form of lamellæ seem to depend upon?

The *osteoclasts;* these are large irregular cells, having two to ten nuclei. These cells are thought to break up and form osteoblasts. In cell reproduction the nucleus divides into two, each nucleus appropriating a portion of the cell-protoplasm. Here the nucleus may divide into many parts, and each nucleus take a portion of the cell-protoplasm. In this manner it is supposed that the osteoclast breaks up and forms osteoblasts.

What are the physical characteristics of blood?

It is a fluid of a reddish color, a little heavier than water, salty to the taste, alkaline in reaction, and having a faint peculiar odor.

Of what elements is it composed?

Of a colorless fluid called *liquor sanguinis or plasma.* This contains quantities of little cells of two kinds, the white and red bloodcells.

What is the estimated number of cells in a cubic millimeter of blood?

5,000,000 of red bloodcells.
10,000 of white bloodcells.

Describe the microscopical appearance of the red bloodcell.

In human blood they look like round biconcave disks having no nuclei. In the blood of cold-blooded animals like the frog the cells are nucleated. All red bloodcells are elastic.

What is the structure of the red bloodcell?

It is composed of a colorless membrane, enclosing a watery solution of hæmoglobin, which gives the characteristic color to blood.

Describe the appearance and structure of the white bloodcell.

They are colorless and finely granular. They have no limiting membrane, and have one or more nuclei.

What peculiar property is possessed by them?

The power of amœboid motion, and the faculty of incorporating little masses of foreign material within their substance.

What are blood plates?

Minute round, colorless, discoid particles floating in blood plasma. Their nature and function is not well understood.

Give the origin of red bloodcells?

In the embryo they are first formed in the mesoblast, and then have nuclei. These nucleated cells are succeeded by non-nucleated ones, which originate in two ways:

First, by intracellular origin.

Second, in the marrow of bones.

How are red bloodcells produced by intracellular growth?

A part of the protoplasm in the mesoblastic cell becomes reddish in color. This coloring matter collects in little globules in the cell. The cell elongates and joins other cells. Then small holes or vacuoles are formed in these cells which finally coalesce finally forming a single large cavity. The little globules of coloring matter enlarge and become full-sized red bloodcells and are now contained in these cavities.

Describe the formation of red bloodcells in marrow.

In red marrow are found nucleated cells smaller than marrow cells. These cells multiply by direct cell division or karyokinesis, their nuclei are colored, and the cells have the power of amœboid motion. Finally the nuclei atrophy and then the corpuscle presents the appearance of a red bloodcell. They probably get into the blood capillaries by virtue of their power of amœboid movement.

What is the origin of white bloodcells?

First they are formed in the mesoblast. In after life it is thought that they are produced in lymphatic glands and tissues of a like construction.

What are the component parts of lymph?

A watery fluid similar to blood plasma, in which are floating nucleated corpuscles and little particles of fatty matter. The nucleated cells resemble the white bloodcells. The fatty matter due to digestive products renders the lymph milky in appearance, and it is then called chyle.

MUSCULAR TISSUE.

What is the arrangement and function of muscular tissue?

It consists of fibres arranged in bundles called muscles. These muscles which form the flesh of animals are the means of producing the active movements of the body.

Into what two general classes are muscle fibres divided ?

Voluntary or striated muscle, controlled by the will. Involuntary or smooth muscles, over which the will has no control whatever.

What is the arrangement of voluntary muscle tissue ?

The muscle fibres are collected into bundles or fasciculi, which fasciculi converge toward the tendinous attachment of the muscle and taken together make up the organ called a muscle.

How are the fasciculi held together ?

By investing areolar tissue. That surrounding the whole muscle being termed the epimysium ; that surrounding the fasciculi, the perimysium, while that extending between but not completely covering the muscle fibres is called the endomysium.

Describe muscle fasciculi.

They are bundles composed of muscle fibres. They are of a prismatic figure giving an angular outline on section. The texture of the muscles being coarse or fine as the fasciculi are large or small.

What is the appearance of muscular fibres ?

They are usually cylindrical, sometimes prismatic, and are usually not more than one and a half inches in length.

Of what elements are voluntary muscle fibres composed ?

The bulk of the fibre is made up of contractile substance upon which lie several nuclei. The whole is enclosed in a delicate membrane called the sarcolemma.

What is the microscopical appearance of muscle substance ?

It is crossed transversely by light and dark bands, hence its name of striated muscle.

With high magnifying powers single fine lines may be seen crossing these bands. That crossing the light band being called *Krause's line*, and that crossing the dark band, *Hensen's line.*

What are sarcous elements ?

By treating a muscle cell with certain chemicals it can be made to separate into plates at each one of the lines called Krause's lines. These plates may be still further separated in a direction parallel with the long axis of the muscle fibre, into tiny prismatic structures, called sarcous elements.

What is the appearance of the muscle nuclei ?

They are oval, have nucleoli, and are arranged with their long axis parallel to the long axis of the muscle cell.

Describe the sarcolemma.

It is a thin, structureless membrane, so delicate that it cannot be seen unless it is separated from the muscle substance by artificial means.

What is the appearance of unstriped or involuntary muscle tissue?

It is made up of spindle-shaped cells interlacing or running in bundles. These cells may appear to have faint longitudinal striations. They have only one nucleus and that is in the centre of the cell substance. The cell is enclosed in an exceedingly delicate sheath resembling the sarcolemma of voluntary muscle.

What is the peculiarity of heart muscle?

It is an involuntary muscle, but its fibres are striated transversely.

Describe the cells of heart muscle.

They are quadrangular in shape, and often branched at one extremity. They are joined end to end in forming the fibres of the muscle. These fibres divide and freely anastomose by means of the branching processes of the cells. The cells are striated transversely and longitudinally, though the transverse striæ are not as distinct as in voluntary muscle. The cells seem to have no sarcolemma or investing membrane.

NERVE TISSUE.

Name the structural elements of nerve tissue.

Nerve fibres and *nerve cells.*

How many kinds of nerve fibres are there and what are they called?

Two; *medullated* and *non-medullated fibres.*

To what nerve systems do they each belong?

The medullated fibres to the cerebro-spinal and the non-medullated fibres to the sympathetic nervous system.

Of what elements is a medullated nerve fibre composed?

Axis cylinder, *medullary sheath*, and *neurilemma* or *sheath of Schwann.*

Describe the axis cylinder.

It is a cylindrical structure, delicately striated longitudinally, and runs through the axis of the nerve fibre. It is supposed to be the path taken by nerve impulse, and that the other sheaths are for its protection. It seems to be a continuous process from the nerve cell to the nerve ending.

What is the medullary sheath?

It is a sheath enveloping the axis cylinder and is made up of a semi-fluid translucent substance called *myelin*. When treated chemically it sometimes appears as though it had a number of incisions through its substance. These are called the *incisures of Schmidt*.

Describe the neurilemma.

It is a thin, structureless tube enclosing the medullary sheath. It is broken up into segments in each of which is an oval nucleus.

What is the node of Ranvier?

At intervals in the course of a nerve fibre there are constrictions which extend through the fibre to the axis cylinder. In this way the medullary sheath is divided completely into segments. The neurilemma is also constricted and these constrictions are joined together by a cement substance which extends to the axis cylinder.

What are the portions of nerve fibre between the nodes of Ranvier called?

Internodes or *interannular segments*.

What are bundles of nerve fibre called?

Fasciculi or *funiculi*.

How is the connective tissue of nerves divided and what is each division called?

The fasciculi are bound together by connective tissue called the *epineurium* or *peri-fascicular connective tissue*. Each fasciculus is surrounded by several concentric lamellæ called the *perineurium*, or *lamellar sheath*. While running between the nerve fibres are prolongations of the tissue of the perineurium called the *endo-neurium* or intra-fascicular connective tissue.

What is Henle's sheath?

It is a tubular sheath formed by endothelial cells cemented together edge to edge and surrounding individual nerve fibres.

How do nerve fibres terminate in nerve centres?

In nerve centres it is supposed that the axis cylinder uninvested by medullary or primitive sheath joins a process of the nerve cell, or that the axis cylinders break up into their primitive fibrils before entering the nerve cells.

How do nerve fibres terminate at their point of distribution?

They may terminate, as in voluntary muscle, in distinctly nucleated flattened structures, called *end plates*, or as in involuntary muscle

break up into fine fibrils. In the finger ends we find them ending in peculiar oval bodies, made up of concentric lamellæ and called *Pacinian* bodies.

Describe the non-medullated nerve fibre.

Non-medullated fibres, or *fibres of Remak*, are naked fibres having no medullary sheath and no neurilemma. They communicate by frequent branches and have on their surfaces flattened elongated nuclei at frequent intervals. They originate in peculiar cells, to be described later. As to their distribution little is known.

Describe nerve cells.

The cell-body is finely granular. They have a large, well-defined nucleus, usually showing a large, shining nucleolus. The cells branch and have one or more processes, and are called *unipolar* or *multipolar ganglion cells*, according to the number of processes. Some of these processes continue as nerve fibres while others break up into fine fibrils. The cells vary considerably as to size and shape.

What is the peculiar point concerning ganglion cells of the sympathetic nervous system?

They are surrounded by a distinct capsule of connective tissue lined with flattened cells resembling endothelium. Through this capsule one or more cell processes pass to become non-medullated nerve fibres.

THE CIRCULATORY SYSTEM.

BLOODVESSELS.

Name the varieties of bloodvessels.

Arteries, *veins* and *capillaries*.

What are the capillary bloodvessels?

They are simple tubes forming the connecting link between the arteries and veins.

What is their structure?

The walls of a capillary vessel is composed of a single layer of endothelial cells joined together, edge to edge, by an intercellular cement substance.

What is an arteriole?

It is the name applied to terminal arteries, and differs from a capillary in that its lumen is larger and it has, besides the layer of cells forming the inner coat, a layer of connective tissue forming the adven-

titia or outer coat. In the larger arterioles there is a middle coat formed by a single layer of smooth muscle cells.

How many coats are there to the larger arteries?—for example, the radial artery?

Three coats are usually described, viz.: The *intima*, *media* and *adventitia*. And in most parts of the body the arteries are surrounded in addition by a connective-tissue sheath. The outer arterial coat is connected to this sheath by slender filaments of connective tissue. The connection is so loose that when the vessel is cut across it retracts a little way into the sheath.

Describe the intima.

It is composed of three parts: An inner portion formed by a single layer of delicate endothelial cells placed edge to edge, an intermediate or subepithelial layer composed of fine fibrillated connective tissue, in the cell-spaces of which are lying a number of branching cells, and finally, a layer of elastic tissue called the *fenestrated membrane of Henle*, which separates the intima from the media, and which is composed of a branching network of elastic fibres.

Describe the media.

It is composed entirely of smooth muscle cells arranged in a somewhat circular fashion about the vessel. The thickness of an arterial wall depends in great part upon the amount of smooth muscle present. In the aorta this layer is replaced in part or entirely by elastic connective tissue.

Describe the adventitia.

It is made of bundles of white fibrous connective tissue, with a variable amount of elastic fibres between. The whole mass of fibres is felted together, and in it ramify the fine bloodvessels or vasa vasorum which carry the blood to nourish the walls of the artery. This coat also contains nerve filaments, which are usually distributed to the middle coat.

In what do the walls of veins resemble arterial walls?

They are made up of three coats—*intima*, *media* and *adventitia*. The component parts of these coats are made up of the same elements as in the arteries.

How do they differ?

The muscular coat is thinner and is intermixed with white fibres, and is not clearly defined from the outer coat. The inner coat is thin-

ner and is thrown up into folds or flaps, one on each side of the vein. These form the valves of veins and are placed at varying intervals along the course of the vessel.

LYMPHATIC VESSELS.

What is the structure of lymphatic vessels?

Their structure is similar to that of the veins. Tracing them from the larger to the smaller vessels toward the peripheral distribution they pass into irregular branching and pouching chambers or channels, the walls of which are made up of a single layer of endothelial cells. These channels are called *lymph capillaries.*

LYMPHATIC GLANDS OR LYMPH NODES.

What are lymphatic glands or lymph nodes?

They are round or oval-shaped bodies of varying size scattered along the course of lymphatic vessels, and through which the contents of these vessels pass. The depressed portion at which the blood and lymphatic vessels enter is called the *hilum.*

What are the parts to be considered microscopically?

Capsule, trabeculæ, cortical and *medullary portions, lymph follicles* or *nodules,* and *lymph cords.*

Of what is the substance of a lymph node composed?

Of *lymphoid tissue.*

Describe the capsule and trabeculæ.

The capsule is the firm investing coat of the lymph node and is composed of dense connective tissue. Running down from the capsule there are a number of fibrous partitions or branches which act as a support to the substance of the node. These branches are called *trabeculæ.*

Describe the cortical or outer portion of a lymph node.

It is composed of lymphoid tissue more dense than in the medullary portions of the node, and scattered through it are the lymph nodules. These are round masses in which the lymphoid cells are arranged in a more dense manner than in adjacent portions.

Describe the medullary portion.

It is the inner portion of the nodule immediately adjacent to the hilum. In it the lymphoid tissue is disposed in cords called *lymph cords.* These cords are suspended from trabeculæ by reticular tissue.

What is the relation of the lymphatic vessels to the lymph nodes?

The afferent vessels split up into branches as they enter the node through the capsule. There they communicate with the spaces between the lymph cords and nodules called *lymph sinuses.* The efferent vessels continuous with these sinuses leave the nodule in a divided manner usually at the hilum. These branches soon unite.

THE SPLEEN.

In studying the spleen what are the points to consider?

Capsule, trabeculæ, Malpighian bodies or *nodules*, the *spleen pulp* and the *bloodvessels.*

Of what is the capsule and trabeculæ composed?

The capsule consists of a dense layer of connective tissue fibres intermixed with a few smooth muscle cells. It enters the hilum with the bloodvessels, acting as their support. It unites with a complicated system of septa and trabeculæ which are produced by processes dipping in from the capsule. The nodules and spleen pulp lie in these spaces between the septa and trabeculæ.

Describe the Malpighian bodies or nodules.

They are rounded masses of lymphoid tissue scattered through the spleen substance.

How are they formed?

By the infiltration of the walls of the smaller vessels with lymphoid cells. The adventitia and connective-tissue sheath which surrounds the artery becomes very loose in texture and becomes infiltrated with lymphoid cells. At certain points the infiltration is very extensive, and nodules of these cells are formed. By this it will be seen that each nodule is traversed by a small artery.

Of what is the spleen pulp composed?

Of multitudes of irregular anastomosing cords called *pulp cords.* Between these cords lie a series of branching channels called *cavernous veins.*

Describe the pulp cords.

They are made up of a delicate reticular tissue, in the spaces of which lie various kinds of cells, viz.: *Lymphoid cells, large colorless cells, with one or more nuclei, red bloodcells,* whole and broken, *large and small pigmented colorless cells.* Also nucleated cells of the same color as the red bloodcells. These are supposed by some to eventually

form red bloodcells. These pulp cords are joined to the Malpighian bodies and infiltrated arterial sheaths and to the connective-tissue septa.

What are the cavernous veins of the spleen?

They are the terminations of the splenic veins. Their walls are made up of branching circular or oblique fibres upon which, here and there, lie endothelial cells of different shapes. The walls of these veins are therefore fenestrated, and are in direct communication with spaces in the pulp cords.

What is the course of the blood in the spleen?

It is supposed after entering the Malpighian nodules to pass through them and enter the spaces in the pulp cords, which are not distinctly walled channels. Then, after circulating around the cells in the cords, it finally finds its way through the fenestrated walls of the cavernous veins and passes out at the hilum by the large efferent vein.

SECRETING GLANDS.

What is the general structure of a secreting gland?

It consists of a layer of epithelium arranged upon a delicate structure or basement membrane, under which there is a layer of finely ramifying bloodvessels. Sometimes the basement membrane is absent.

How may the extent of a secreting surface be increased?

By a protrusion of the secreting surface into simple or compound papillæ, or by a recession of this surface in the form of tubules or saccules, simple or compound.

What is the arrangement or plan of a compound gland?

The sides of a tubule become sacculated, or the tubule itself may branch.

What is a racemose gland?

It is a gland composed of many alveoli, opening in clusters into the extremities of a branched tube or excretory duct.

What is the arrangement of a compound tubular gland?

The gland tubules divide again and again into branches which retain their tubular character. The kidney is an example of this type of gland.

How do gland cells in a state of activity differ from those in a state of rest?

A gland-cell while in a condition of rest becomes filled with the material for secretion, which usually gives the cell a granular appearance. During the stage of activity the material which has accumulated in the cell is discharged. The cell becomes clear, or may be broken up in the process.

THE MUCOUS MEMBRANE AND SKIN.

MUCOUS MEMBRANE.

Where are the mucous membranes situated?

They are found lining all passages and cavities of the body, which communicate with the exterior.

What are the two main divisions of mucous membrane?

The *gastro-pneumonic membrane*, beginning at the lips, lining the mouth, trachea and lungs, the œsophagus and entire alimentary tract to the rectum, where it meets the skin again. The *genito-urinary membrane*, beginning at the meatus urinarius and investing not only the entire urinary tract of both sexes, but also lining the organs of generation.

What are the physical properties of mucous membranes?

They are nearly opaque and are easily torn on account of the small amount of tenacity and elasticity possessed by them.

What is the structure of mucous membrane in general?

The surface is covered with epithelium, which, when stripped off, leaves the corium as in true skin.

What are the different varieties of cells covering mucous membranes?

They may be scaly and stratified or columnar or ciliated.

What portions of a mucous membrane are concerned in producing its proper secretion?

When the surface is composed of stratified epithelium the mucus is secreted by *glands* in the membrane lined with cylindrical or polyhedral-shaped cells. When the surface is made up of a layer of cylindrical or ciliated epithelium the mucus is secreted by *cells* in this same layer, and the *glands* in the mucous membrane are devoted to the secretion of some special product.

When mucus is formed in a layer of cylindrical or ciliated cells how is it discharged?

It is extruded from the apparently open end of the cell as a little droplet. These cells are swollen, and from their shape are called goblet or chalice cells.

What is the situation of the corium?

It is a membrane composed of connective or retiform tissue, bounded on the side next the epithelium by a basement membrane and separated from the sub-mucous coat by a thin layer of involuntary muscle (*muscularis mucosæ*).

What is the structure of the basement membrane?

Where it is present it is made up either of a layer of flattened cells, which may lie edge to edge, forming a perfect sheet, or of a layer of branching cells which when arranged together have spaces between them.

What is the structure of the corium?

It is made up of fibrous connective tissue, which may be rather dense and tough, or may consist of retiform connective tissue-containing patches of lymphoid tissue.

What is the sub-mucous coat?

It is a layer of areolar connective tissue between the muscularis mucosæ and the outer muscular wall of a cavity as seen in the intestine.

What is the distribution of bloodvessels, lymphatic vessels, and nerves in mucous membrane?

The vessels are most abundant in the sub-mucous coat, and send branches into the mucous membrane proper. The nerves are principally distributed to the muscularis mucosæ and may send filaments up between the epithelial cells of the mucous membrane. Before dividing they may in many parts be collected to form a gangliated plexus in the sub-mucous coat, as, for example, Meissner's plexus in the walls of the intestine.

Describe the free surface of mucous membranes.

They may be plain and smooth, or they may be beset with little eminences named *papillæ* or *villi*, derived from the corium.

What forms of secreting glands occur in the mucous membrane?

Simple, *tubular* and *racemose* glands.

THE SKIN.

Of how many layers does the skin consist?

Three: Epidermis or *scarf skin; cutis vera* or *corium*, and the *subcutaneous layer.*

Of what form of epithelium is the epidermis made up and into how many layers is it divided?

It is composed of stratified epithelium and is divided into four layers, viz.: *Horny layer, stratum lucidum, stratum granulosum* and *Malpighian layer* or *rete mucosum.*

Describe the Malpighian layer.

The deeper cells of this layer are elongated and placed perpendicular to the surface of the corium with which they are in contact. The remaining portion of this layer is composed of roundish or polyhedral-shaped cells. These cells have fine channels between them bridged across by fine processes passing from cell to cell. These cells are called spiny or prickle cells. The pigment is contained in this layer.

What is the rete Malpighi?

If a section of the Malpighian layer is made parallel to the surface of the skin and cutting through the tops of the papillæ of the corium which extend up into this layer, a network composed of certain of the cells of the Malpighian layer is seen. This network is called the *rete Malpighi.*

Describe the other layers of the epidermis?

The cells next above the Malpighian layer become filled with granules and are called the *stratum granulosum.* Next above this layer the cells appear to have become clearer, and their outlines and nuclei indistinct. This is the stratum lucidum. The external or horny layer is composed of hard, flat scales showing no nuclei. These scales are modified cells that have been derived from the deeper layers. As the epidermis is non-vascular, the cells as they approach the surface become desiccated and are thrown off, successive layers forming below to take their place.

What layer contains pigment and gives color to the skin as in the negro?

The deeper layers of the rete mucosum.

What is the structure of the corium?

It is a sentient, vascular, fibrous layer, made up principally of interlacing bundles of white fibrous tissue among which ramify bloodvessels,

lymphatics and nerves. There are also some elastic fibres in this layer. Upon its free surface the corium is beset with papillæ which fit up into the under layer of the epidermis.

What is the structure of the subcutaneous layer?

The fibres of the corium become more loosely arranged and the spaces between them are filled with fat (*panniculus adiposus*). This layer serves to attach the corium to the parts underneath. In this subcutaneous layer are the sweat glands, hair follicles, and some of the nerve endings.

How are the bloodvessels and lymphatics distributed to the skin?

They branch and subdivide in the subcutaneous layer, and send fine branches up into the papillæ of the corium.

How do nerve fibres terminate in the skin?

They branch and subdivide in the subcutaneous layer. Some fibres may terminate as tactile corpuscles or Pacinian bodies in the true skin; some may be distributed to the hair follicles and glands of the skin, while others pass up into the Malpighian layer and seem to divide still further. The precise mode of termination of these ultimate nerve fibres has not been definitely settled.

What are the nails and hairs?

They are produced from the epidermis, and are modified growths of the horny layer.

Describe the structure of the nail.

It consists of a body and root, the former lying upon the modified Malpighian layer or nail bed. The root sets into a pocket of skin, the corium of which is called the matrix. The Malpighian layer at the root of the nail is thick, and gives a whitish color to the crescentic-shaped spot at the base of the nail, called the lunula.

What are the points to consider in regard to hair?

The *shaft*, *root* and *bulb*. The root and bulb are placed in oblique tubular depressions in the skin called hair follicles.

What is the structure of the hair shaft?

It is composed of three parts: A central or medullary portion, composed of cuboidal or flattened cells loosely arranged. A cortical portion, made up of tough, flattened cells closely packed together, and having pigment granules of various colors in and between them. The outer layer or cuticula of the hair shaft is composed of non-nucleated scalelike cells, which overlap one another like scales on a fish.

What is the root and what the bulb of the hair?

The root is that portion continuous with the shaft that is in the hair follicle, and the bulb is the dilated portion of the hair where it ends in the follicle. The end of the bulb rests upon and surrounds, at the top and sides, a projection of the connective tissue wall of the follicle, called the *papilla*.

What is the structure of a hair follicle?

The wall is formed first by a layer of connective tissue continuous with the corium of the skin. Within this is a thin, transparent layer called the *vitreous membrane*. Within this follicular wall is the root sheath proper, composed of two layers. The outer layer is formed by a dipping down into the follicle of the Malpighian layer of the epidermis. The inner layer is made up in turn of two other layers, of which the outer is composed of cells resembling those in the horny layer of the epidermis and is called *Henle's sheath*. The inner layer is composed of polygonal or flattened cells, having elongated nuclei. This is called *Huxley's sheath*, and belongs properly to the hair itself.

What is the erector pili?

It is a bundle of involuntary muscle running from the corium obliquely to the hair follicle, and which, by contracting, serves to raise the hair erect.

Describe the structure of sebaceous glands.

They are racemose glands, the alveoli of which are lined with large polyhedral cells. Their ducts, lined with polyhedral or flattened cells, open, as a rule, into a hair follicle near the surface of the skin.

Describe the sweat glands.

They are simple tubular glands lined with polyhedral or cuboidal cells. They terminate in the subcutaneous tissue, and at their point of termination are coiled up into a roundish mass, and are surrounded by loose areolar connective tissue.

ORGANS OF DIGESTION AND ALIMENTARY TRACT.

THE TEETH.

Of what is a tooth composed?

Of three calcified tissues: *Enamel, dentine* and *cement*, or *crusta petrosa*.

What is the structure of enamel?

It is composed of elongated, hexagonal prisms, set vertically. These prisms are marked by slight transverse shadings.

What is the structure of dentine?

It is composed of a hard, calcareous material resembling bone, but having no lacunæ or Haversian canals. It is pierced everywhere by fine canaliculi radiating out from the central cavity of the tooth. This cavity contains the tooth pulp. Along the sides of this pulp cavity lie round or oval cells which send branches into the canaliculi in the dentine and also into the pulp. They are the analogues of bone cells, and are called dentine cells or odontoblasts.

Describe the tooth pulp.

It is a soft, vascular tissue containing nerve fibres and irregular-shaped and branching cells.

What is the cement or crusta petrosa?

It is a layer of lamellated bone having lacunæ and canaliculi but no Haversian canals. This layer surrounds the root of the tooth.

THE TONGUE.

What is the structure of the tongue?

In great part it is composed of striated or voluntary muscle fibres. It is covered with mucous membrane, the surface of which, as in the rest of the mouth, is covered with stratified epithelium. The free surface of the tongue is covered with small papillæ called *conical* and *filiform papillæ*. Scattered here and there are larger or fungiform papillæ. Near the base of the tongue there are twelve or thirteen large papillæ arranged in a V shape and called *circumvallatæ papillæ*. Between the superficial muscular fibres, small tubular glands may be seen, running to the surface of the tongue.

Describe these different papillæ.

The fungiform papillæ are capped with stratified epithelium, while in the filiform variety the papillæ are fringed with fine filaments springing from the epithelial cells covering them. The circumvallatæ papillæ project above the mucous surface of the tongue and are surrounded by a groove. They are covered by stratified epithelium.

What are taste buds?

They are small, oval clusters of epithelial cells situated in the covering of the sides of the circumvallatæ papillæ. These taste buds

are connected with the terminal filaments of the gustatory nerve, and are made up of two varieties of cells, viz.: gustatory cells of a delicate fusiform shape and sustentacular cells of flattened shape located between the former.

Both varieties have a single nucleus. The gustatory cells at their free ends terminate in a fine cilium like process. Their proximal ends are usually branching and are believed to be directly connected with the entering nerve fibres.

SALIVARY GLANDS.

Name the salivary glands.

Parotid, *sub-maxillary* and *sub-lingual.*

What is the structure of a salivary gland?

It is composed of a number of lobules surrounded by a loose connective tissue. Each lobule is made up of a group of somewhat saccular alveoli, from each of which a duct passes, uniting with the other ducts to finally pass into the main excretory duct of the gland. Each alveolus is surrounded by a basement membrane, upon which are arranged large polyhedral cells with single nuclei. These cells may appear to fill the alveolus entirely. Between these cells and the basement membrane are crescentic masses of flattened cells, called the "*crescents of Gianuzzi.*" They are supposed to take the place of the gland cells when they are destroyed. The ducts are lined with cylindrical epithelium.

PHARYNX.

What is the structure of the pharynx?

It is a fibro-membranous tube surrounded by voluntary muscle tissue and lined by mucous membrane. The upper portion has ciliated epithelium continuous with that of the nasal passages. Below the level of the soft palate it is lined with a layer of stratified epithelium. In certain parts it contains a large amount of lymphoid tissue in the mucous membrane.

ŒSOPHAGUS.

Describe the structure of the œsophagus.

It has an outer fibrous coat within which is a muscular coat in two layers, the outer of which runs longitudinally, and the inner in a circular direction. In the upper part of the œsophagus the muscle fibres are striated, while in the lower portion they are non-striated and

continuous with the muscular coat of the stomach. Within the muscular coat is a layer made up of areolar connective tissue, called the sub-mucous coat. This contains numerous mucous glands and is separated from the mucous membrane by a thin layer of unstriped muscle (*muscularis mucosæ*). The lining coat or mucous membrane, consists of two parts, an outer part or corium composed of areolar connective tissue in which the bloodvessels and lymphatics are distributed, and an inner part made up of stratified epithelium into which microscopic papillæ from the corium project.

DIGESTIVE TRACT.

What is the general structure of the digestive tract?

It is a long tube, continuous at either end with the external surface of the body, and differing in size in different portions of its length. Where it lies in the abdominal cavity it is covered by a serous coat, the inner portion of which is fibrous, and the surface of the outer part is covered with a layer of delicate endothelial cells. Throughout its whole extent the digestive tract is surrounded within the serous coat by layers of involuntary or unstriated muscle, one layer running longitudinally with, and the other transversely to the long axis of the canal. In the muscular wall of the stomach a third layer is made out between the other two, in which the muscle fibres run obliquely. Within the muscular coat is the sub-mucous coat, composed of areolar connective tissue, separated from the mucous membrane by a thin layer of smooth muscle (*muscularis mucosæ*). Some of the fibres of the muscularis mucosæ may run up between the glands of the mucous membrane.

Where are the principal differences in structure of the wall of the digestive tract apparent?

In the mucous membrane. The other portions of the wall are about the same all the way throughout the tract.

What is the structure of the mucous membrane lining the stomach?

On its free surface it is covered by cylindrical cells, between which open the ducts of numerous tubular glands. The gland tubules extend down to the muscularis mucosæ and are single or branched. In the pyloric end of the stomach the glands and their ducts are lined with cylindrical epithelium. In the cardiac end the ducts are lined with cylindrical cells, while the gland tubules are lined with roundish or polyhedral-shaped cells that are finely granular. Between the cells lining the tubules and the basement membrane upon which they rest

are seen here and there single, large, oval cells, each having a large nucleus. These are called *oxyntic cells;* they are supposed to secrete the free acid of the stomach and are a characteristic feature of the cardiac end. Little nodules of lymphoid tissue, sometimes visible to the naked eye, are seen in the mucous membrane and are called *lenticular glands* or *nodules.*

How are the blood and lymphatic vessels distributed to the stomach and intestines?

They branch and subdivide in the sub-mucous coat and send branches up between the gland tubules.

How are the nerves distributed?

Branches from the sympathetic and pneumogastric anastomose and form the plexus of Auerbach in the muscular coat of the canal, dividing and anastomosing again in the sub-mucous coat to form Meissner's plexus; they are finally distributed between the gland tubules.

What are the peculiarities of the mucous membrane of the small intestine?

It is much more complex than the mucous membrane of the stomach. The connective-tissue framework of the mucous membrane is more richly infiltrated with lymphoid cells than that of the stomach. Situated in this mucous membrane are numerous tubular glands (*crypts of Lieberkühn*). Between them the mucous membrane projects up into cylindrical or cone shaped bodies, called *villi.* In the sub-mucous coat of the upper part of the small intestine are a number of racemose glands called *Brunner's glands.*

Describe the structure of the villi of the small intestine.

They consist of a connective-tissue framework infiltrated with round cells, and in this loose structure the bloodvessels and lymphatics ramify. The villi are covered with a layer of cylindrical cells, the free borders of which are quite thick.

Some of the cells seem to have lost this free border and to have become goblet shaped on account of a swelling up and expulsion of the cell-protoplasm; they are called *goblet cells.* Smooth muscle cells pass up into the villi from the muscularis mucosæ.

What is the structure of Brunner's glands?

They are racemose glands having rather oval-shaped alveoli lined with polyhedral-shaped epithelium. The ducts are lined with cylindrical epithelium. These glands probably secrete nothing but mucus.

Give the structure of the crypts of Lieberkühn.

They are simple, straight, tubular glands, lined with cylindrical-shaped cells.

What are the solitary follicles?

They are little masses of lymphoid tissue placed in the mucous membrane of the small intestine. They sometimes extend down to the sub-mucous coat and are closely connected with the lymphatic vessels. No villi cover them.

What is a Peyer's patch?

It appears to be an aggregation of these solitary follicles arranged together in large, oval masses in the lower portion of the small intestine. The lymphoid tissue of which each is composed is not covered with villi.

What is the structure of the mucous membrane of the large intestine?

It contains numerous straight tubular glands similar to the crypts of Lieberkühn in the small intestine. There are also numerous patches of lymphoid tissue in it similar to the solitary follicles in the small intestine.

LIVER.

What are the distinctive elements that make up the liver?

Connective tissue, *liver-cells*, and the *blood*, *lymphatic and gall vessels.*

Describe the connective tissue of the liver.

The organ is covered by a dense connective-tissue coat or capsule. A certain amount of this tissue is present accompanying the blood-vessels and is called *Glisson's capsule.* Lastly, an exceedingly small amount is formed about the hepatic veins and between the liver cells.

Describe the shape and arrangement of the liver cells.

These cells, which form the parenchyma of the liver, are irregularly polyhedral in shape. They are granular and have a large, distinct nucleus. They are arranged in polyhedral masses or lobules. The cells in these lobules are arranged in single or double rows radiating from the centres of the lobules. In the liver of the pig the lobules are separated from one another and entirely surrounded by the connective tissue of Glisson's capsule. In the human liver this connective tissue is not so abundant, occurring only in patches in the spaces between the liver lobules.

What is the blood supply of the liver?

It is supplied by the hepatic artery and the portal vein. The vein carries the bulk of the blood passing to the liver.

How do these vessels terminate in the liver?

They divide and subdivide, and, surrounded by the connective tissue of Glisson's capsule, ramify through the liver structure in the spaces between the lobules; hence they are called the *interlobular* vessels. The terminal branches of the vein and artery break up into capillaries which pass through the liver lobules between the radiating rows of hepatic cells, and pour their blood finally into the vein, which is in the centre of each lobule.

What is the vessel occupying the centre of a liver lobule called?

It is called the *intra-lobular vein*, and is the beginning radicle of the hepatic veins which are formed by the union of these intra-lobular veins. Through these the blood is conveyed away from the liver.

How are the lymphatic vessels distributed to the liver?

They form an abundant network in the capsule and accompany the bloodvessels in the patches of Glisson's capsule in the interlobular spaces or spaces between the lobules. These vessels are connected with minute lymph spaces within the lobules. Small, irregular nodules of lymphoid tissue occur in the interstitial tissue of the liver.

Describe the origin of the gall passages.

The intra-lobular gall passages begin between liver-cells within the lobules. They have no walls of their own, but are simple channels grooved in the walls of contiguous liver-cells. They never come in contact with the blood capillaries, being separated from them by at least one row of liver cells. As these bile capillaries pass out to the interlobular spaces they unite to form small bile ducts lined with flattened, polygonal-shaped cells. These small bile ducts unite to form the larger gall passages which are lined with a distinct mucous membrane.

PANCREAS.

Describe the structure of the pancreas.

It is a racemose gland, resembling the salivary glands in structure. The alveoli, however, instead of being saccular, are tubular in form. The cells lining these alveoli are columnar or polyhedral in shape. The connective tissue of the gland is arranged more loosely than in the salivary glands.

THE DUCTLESS GLANDS.

THYMUS.

What is the structure of the thymus?

It is covered with a dense connective-tissue coat or capsule, from which trabeculæ run down into the cortical or outer portion of the gland dividing it into chambers. These chambers are filled with masses of lymphoid tissue called follicles. In the inner or medullary portion of the gland the follicles are fused together into one mass of lymphoid tissue. Scattered in this tissue in the medullary portion are found concentrically-arranged clusters of flat epithelial cells called the "*corpuscles of Hassall.*"

THYROID.

What is the structure of the thyroid?

It consists of two lobes united by a commissure, and surrounded by a dense connective-tissue capsule. The gland is made up of a series of round or oval-shaped alveoli which have no excretory ducts. These alveoli are filled with a translucent material which may be converted into colloid. They are lined with a layer of cuboidal cells resting upon a delicate basement membrane. These cells may become flattened from pressure of the contents of the alveoli. Bloodvessels ramify between the alveoli.

SUPRA-RENAL CAPSULE.

Describe the structure of a supra-renal capsule.

The organ is enclosed in a firm connective-tissue capsule in which are numerous involuntary muscle cells. Fine processes or septa of connective tissue run down into the gland from the capsule, and, being joined by delicate transverse bands, divide the cortex into chambers of various shapes. Beneath the capsule these chambers are small and irregular in shape; deeper in, the chambers are long and narrow; while still further in, at the inner border of the cortex, they are small and irregular. In the medullary portion of the gland the sustaining structure is a delicate reticular tissue. These spaces in the supra-renal capsules are filled with the parenchyma cells of the organ. In the cortical chambers they are large, polyhedral and granular; there are also seen here a few small cylindrical or cuboidal cells. The cells in the *long chambers* contain *fatdrops*, and those in the *inner zone of the cortex* contain *pigment*. The cells in the medullary portion of the gland are spheroidal, angular or branched. The bloodvessels and nerve fibres are numerous.

THE RESPIRATORY SYSTEM.

TRACHEA.

What is the structure of the trachea?

It is a tube, the outer portion of which is composed of fibrous tissue. At intervals in its course this is rendered firm and stiff by incomplete rings of hyaline cartilage, joined at their free ends by smooth muscle fibres. The inner coat of the trachea is mucous membrane and consists of a layer of cylindrical, ciliated cells resting upon a basement membrane, under which is the corium, made up of loose connective tissue, containing cells of various shapes. The outer portion of the mucous membrane is made up of a layer of elastic tissue. The sub-mucous coat, which is between the outer fibrous coat and the mucous membrane, is composed of loose areolar tissue in which numerous mucous glands are imbedded.

BRONCHI.

In what respect does the structure of the bronchi differ from that of the trachea?

The larger bronchi are about the same in structure with the exception that between the mucous membrane and the sub-mucous coat there is a layer of smooth muscle cells.

How do the bronchi change in structure as they are followed to their ultimate ramifications?

The outer connective-tissue coat becomes thinner, the cartilage plates become smaller, more infrequent and finally disappear, as also do the mucous glands. The other layers grow gradually thinner, and finally there is left a single row of cylindrical, ciliated cells upon the basement membrane, surrounded by a few muscle cells in the connective-tissue layer. In the smallest tubes the wall is made up of a few connective-tissue fibres and muscle cells, and lined with cuboidal, ciliated, and lastly, with flattened epithelial, cells.

LUNG.

Describe a pulmonary lobule.

It is pyramidal in shape, and is better seen upon the surface of the lung. This surface appears to be divided by narrow lines into irregular, polygonal-shaped spaces, which are the bases of these pyramidal-shaped pulmonary lobules. Within the lung these lobules are not so regular in shape. They are all separated one from another by narrow connective-tissue septa, and each lobule is made up of a collection of air vesicles and air passages grouped around a terminal bronchus.

How do the bronchi enter these lobules?

They may enter from any side and after entering they break up into irregular tubular cavities (the air passages). The walls of these cavities pouch out and form the air vesicles or alveoli.

Describe the structure of the wall of an air vesicle.

In fœtal life each vesicle or alveolus is lined with cuboidal or roundish-shaped cells which, when breathing is begun, become flattened so as to cover the wall of the expanded air vesicle. In the adult lung the walls of the alveoli are composed of a wide-meshed net of elastic fibres, the meshes of which are filled with a homogeneous structure containing a few oval nuclei. Upon this layer are seen cells of two kinds, viz.: some that are round and granular, and larger, irregular-shaped nucleated cells that are very thin and transparent.

Describe the blood supply of the lung.

Blood is carried to the lungs by the pulmonary and bronchial arteries. That from the bronchial artery being for the nourishment of the lung tissue. The pulmonary artery divides and subdivides until it forms a delicate capillary network which lies between the walls of the air vesicles. From this network the blood is returned by the pulmonary veins.

PLEURA.

What is the structure of the pulmonary pleura?

It is composed of a layer of dense fibrous tissue well supplied with blood and lymphatic vessels. Here and there are seen in it little nodules of lymphoid tissue. This is the "deep" layer. The superficial layer is "endothelial" in character.

THE URINARY ORGANS.

KIDNEY.

What is the general structure of the kidney?

In the cut section of a rabbit's kidney a low magnifying power will show that the outer part is covered with a dense connective-tissue coat called the *capsule*. Within this is a broad zone of kidney tissue called the *cortex*. The remaining or inner portion of the kidney is called the *medullary* portion or the *Malpighian pyramid*, as it terminates in a blunt projection in the pelvis of the kidney. This projection is called the *papilla* and forms the apex of the Malpighian pyramid, the base of

which is in contact with the cortex. Running up into the cortex almost to the capsule from the base of the Malpighian pyramid are delicate rays called *medullary rays*. The whole structure as described is called a *renculus*. While the rabbit's kidney consists of only a single renculus, the human kidney consists of as many renculi as there are papillæ.

What kind of a gland is a kidney?

A compound tubular gland, made up of numerous branching tubules called *uriniferous* tubules which, with the cells lining them, constitute the parenchyma of the kidney.

How is the blood distributed to the kidney?

The bloodvessels enter at the bases of the medullary pyramids and divide into large arching trunks between the cortex and the base of the Malpighian pyramid. Springing from the convex side of these arches small branches called interlobular arteries run up through the cortex between the medullary rays. Small twigs are given off from these interlobular arteries, which enter the Malpighian bodies as afferent arteries; breaking up into a capillary network they pass out of the Malpighian body as a single vessel called the *efferent vessel*. The efferent vessel then splitting up envelopes the uriniferous tubules in a capillary meshwork. A similar network is also seen under the capsule in the cortex and is known as the *stellate plexus* or the "*stellulæ Verheyenii*." The blood is then collected in veins which follow along the interlobular arteries. The medullary portion of the kidney is supplied with blood from the *concave* side of the above-mentioned arches, the vessels between the tubules being called the *vasæ rectæ*.

Give the names and location of the different portions of a uriniferous tubule.

In the cortical portion between medullary rays surrounding the Malpighian tuft is a dilatation called the *capsule of Bowman*. Continuous with this is the first convoluted portion of the tubule, which entering a medullary ray narrows and runs down as the descending limb of Henle's loop. It then ascends in the same ray as the ascending limb of Henle's loop comes out into the cortical portion between the rays as the second convoluted portion or intercalated tubule, and again enters the medullary ray as the straight or collecting tubule. These collecting tubules are at first narrower than the convoluted tubules, but uniting one with another they finally terminate in the apex of the Malpighian pyramid in a number of large tubules called

the *ducts of Bellini*, and empty into the cavity of one of the calices of the pelvis of the kidney.

Of what does the Malpighian tuft or glomerulus consist?

Bowman's capsule is composed of a basement membrane continuous with the basement membrane of the convoluted tubule. An arterial twig (*the vasa afferens*) from the interlobular artery enters it at one side, and breaks up into a capillary network or tuft. The blood from this tuft is collected into a vein (*the vasa efferens*) which leaves the capsule near where the afferent artery enters. The capsule is lined with a layer of flattened epithelium which is also reflected over the capillary tuft of bloodvessels which is *the glomerulus.*

Describe the cells lining the different parts of a uriniferous tubule.

The cells lining the convoluted portions consist of large, granular, striated cells, whose outlines are not well defined, and which nearly fill the lumen of the tubule. In the descending limb of Henle's loop the lining cells are flat and transparent, while in the ascending limb they are pyramidal or short and cylindrical in shape and are granular.

The collecting tubules are lined with cylindrical- or, in some parts, with cuboidal-shaped cells.

Where is connective tissue found in the kidney?

In the capsule, and lining the sinus. It is also found along the walls of the larger bloodvessels and around the glomeruli.

URETER.

What is the structure of the ureter?

The outer coat is composed of fibrous tissue. The middle coat is composed of three layers of involuntary muscle, the outer and inner layers running in a longitudinal direction, and the middle layer in a circular manner. The inner coat of the ureter is a mucous membrane made up of areolar tissue and covered with transitional epithelium.

BLADDER.

What is the structure of the wall of the bladder?

It consists in part of a serous coat derived from the peritoneum; of a muscular coat made up of three layers of involuntary muscle, the principal fibres of which run longitudinally and circularly. It is lined with a strong mucous membrane, which is covered with a layer of transitional epithelium continuous with the lining wall of the ureter

THE MALE ORGANS OF GENERATION.

PENIS.

What are the parts of the penis to be considered?

The *corpora cavernosa*, the *corpus spongiosum*, and the *urethra*.

Describe the structure of the corpora cavernosa and the corpus spongiosum.

Both portions of the organ are surrounded by a dense connective-tissue sheath, from which septa or trabeculæ blended with smooth muscle tissue pass inwards and form an intricate series of spaces filled with blood and lined with flattened epithelium. The urethra runs through the corpus spongiosum in a longitudinal direction.

Describe erectile tissue.

It may consist simply of a collection of larger and smaller veins, or, of numerous large and small irregular communicating cavities separated by narrow interlacing bundles of connective tissue and smooth muscle fibres. These spaces are lined with endothelium, and are in communication with arterial trunks and capillary bloodvessels. Normally they contain but little blood and appear as narrow slits in the tissue. When filled with blood they appear as spheroidal or elongated cavities, and cause a marked increase in the size of the part in which they are located.

URETHRA.

Describe the structure of the urethra.

It is composed of three coats:

The muscular coat, which is made up of two layers of smooth muscle, the fibres of which run longitudinally and circularly.

The sub-mucous coat, composed of areolar tissue, is so rich in blood-vessels that it resembles erectile tissue.

The mucous membrane composed of fibrillar connective tissue contains many elastic fibres and cells. The cells which cover the mucous membrane differ in shape in different parts. At the meatus and fossa navicularis they are flat. In the portion traversing the corpus spongiosum (spongy portion) they are cylindrical. In the prostatic portion of the urethra they are pear shaped, polygonal and flattened. They lie in several layers and resemble the layer of transitional cells lining the bladder. Here and there in the spongy portion of the urethra are small, irregular depressions in the mucous membrane called *lacunæ Morgagni*. Imbedded in the mucous membrane are also seen racemose

glands, called *Littrés glands*, extending sometimes to the muscular coat. Their ducts, either short or long, and tortuous, open on the surface of the mucous membrane. In the posterior segment of the spongy portion of the urethra the ducts of Cowper's glands open. In the prostatic portion the mucous membrane is pierced by the prostatic and ejaculatory ducts.

What is the structure of Cowper's glands?

They are compound racemose glands, the alveoli of which are lined with cylindrical epithelium.

PROSTATE.

Describe the structure of the prostate.

It is an organ that is partly muscular and partly glandular. It is surrounded by a dense capsule of connective tissue, within which is a layer of smooth muscle tissue. Between bands of smooth muscle tissue, of which the organ is largely composed, are lobules of gland tissue of the racemose variety. The alveoli are long and irregular in shape and are lined with cylindrical cells, as are the ducts also. As the ducts approach the urethral mucous membrane these cells become flattened.

TESTICLE.

What is the general structure of the testicle?

It is a tubular gland covered with a dense connective-tissue coat (*the tunica albuginea*). From the tunica incomplete septa pass in, dividing the gland into a number of communicating cavities, and uniting at the posterior superior part form a mass of dense connective tissue (*corpus Highmori*). In the cavities between the septa are the seminiferous tubules, which, as they approach the corpus Highmori, become narrow and straight (*tubuli recti*) and are lined with cylindrical cells. On entering the corpus Highmori the tubuli recti form a series of communicating channels (*rete testis*) lined with flattened epithelium. These channels, on emerging from the *corpus H.*, form a number of conical masses (*coni vasculosi*) of which the head of the epididymis is made up. These tubules in the epididymis are lined with cylindrical ciliated epithelium. From the *head* of the epididymis proceed the body and tail which are also lined with cylindrical ciliated cells. From the tail finally is formed a single tube—*the vas deferens.*

Describe the structure of a seminiferous tubule and the tissue about it.

These tubules are quite long when unravelled. They lie in a loosely-arranged connective tissue containing many bloodvessels and cells of various forms, some of which may be pigmented. The tubules have a well-defined basement membrane upon which the lining cells are placed, several layers thick. When in a state of rest the cells upon the basement membrane or membrana propria are large, granular and well defined, having a distinct nucleus. Upon this layer lie two or three layers of small nucleated cells with poorly-defined cell-bodies. Among these cells, when they are in a state of activity, are seen bundles of spermatozoa with their tails projecting into the lumen of the seminiferous tubules. The spermatozoa are believed to be formed from the cells in the outer layers.

What is the structure of a spermatozoon?

It consists of a pear-shaped body called the head. To the large end of the head is attached a slender filiform process called the tail. Between the two and next to the head is a short segment called the middle piece.

What is the structure of the vas deferens?

It is a thick, walled tube surrounded with a coat of smooth muscle tissue, the outer layer of which runs in a longitudinal, and the inner layer in a circular, direction. It is lined with a mucous membrane covered by a layer of cylindrical non-ciliated epithelium.

THE FEMALE GENERATIVE ORGANS.

VAGINA.

Of how many layers is the vagina composed, and what is the structure of each?

Three. An outer fibrous layer composed of fibrous connective tissue with elastic fibres in it. A middle layer made up of smooth muscle cells arranged longitudinally and circularly, and an inner layer, the mucous membrane, made up of loose connective tissue containing elastic fibres. The mucous membrane lies in folds or ridges and is covered with a layer of stratified epithelium. It has in its deeper portions venous plexuses, which give it the appearance of erectile tissue.

UTERUS.

Of how many and of what layers does the uterus consist?

Three. A serous coat from the peritoneum covers it partly. The major portion of the uterine wall is composed of a thick layer of interlacing smooth muscle cells with a small amount of connective tissue among them. The inner layer is the mucous membrane, made up of a delicate network of fibres, between which lie a great number of round, spindle-shaped and branching cells. The surface of the mucous membrane is covered with cylindrical ciliated cells which also line the tortuous single or branched tubular glands that are imbedded in it. In the cervical portion the mucous membrane lies in folds (*plicæ palmatæ*) and is rendered firmer by its connective-tissue framework. The glands are fewer and are lined with short cylindrical or cuboidal cells. The ciliated cells from the body extend to the lower portion of the cervical canal, where they become continuous with the flattened cells lining the vagina.

FALLOPIAN TUBE.

Describe the three layers of which the fallopian tube is formed.

The outer serous layer is composed of loose, fibrous, connective tissue with elastic fibres. Its free surface is covered with endothelial cells. The middle or muscular layer consists of an inner thick circular, and an outer thin longitudinal, layer of smooth muscle. The inner layer is the mucous membrane, which is thrown up into complicated folds. It is composed of delicate connective tissue containing many cells. Its surface is covered with a single layer of cylindrical ciliated cells. Beneath the mucous membrane is a thin layer of smooth muscle (*muscularis mucosæ*) and a sub-mucous coat of delicate areolar tissue, which binds it to the muscular wall.

OVARY.

What is the general structure of the ovary?

It consists of a dense connective-tissue stroma, in which are numbers of alveolar spaces called *Graafian follicles*, each containing an ovum. The surface of an ovary is covered with a single layer of cylindrical epithelium (*the germinating epithelium*). In the outer or cortical portion the connective-tissue stroma is more dense than in the inner or medullary portion. The bloodvessels are very abundant in this inner portion. Scattered, smooth muscle cells also are found in the medullary portion.

Describe the parts of a Graafian follicle.

The connective tissue of the stroma of the ovary is arranged to form a well-defined wall (*theca folliculi*). This wall is lined with several layers of round or irregular-shaped cells forming the membrana granulosa. At one side some of these cells are collected into a mass (*cumulus proligerus*) which contains the ovum. The cavity of the follicle is filled with a semitransparent fluid, which, by its increase, distends and ruptures the follicle at a menstrual period and sets free the ovum.

How are the Graafian follicles formed?

In embryonic life the stroma of the ovum grows very fast and entangles in its meshes groups of the germ epithelium which covers the organ. These cells are at the same time increasing in number by cell proliferation. The stroma becomes arranged around a group of these irregular-shaped cells to form the *theca folliculi*. The cells begin to increase in number, one being developed more perfectly than the rest, to form the ovum, and is situated in the centre of the mass. As several layers of cells are formed the ovum is placed eccentrically. The cavity of the follicle now begins to appear, first as a narrow slit, but growing wider as fluid accumulates.

What is the structure of the ovum?

It is an example of a cell of the most highly developed type. The cellwall, consisting of a thick hyaline membrane showing a delicate radial striation, is called the *zona pellucida*. The cell-protoplasm, which is granular, is called the *vitellus*. The cell nucleus, located in the protoplasm, is transparent and vesicular in appearance, and is called the *germinal vesicle*. Inside this nucleus is a dark nucleolus called the *germinal spot*.

What is the corpus luteum?

When the Graafian follicle ruptures, its cavity is filled with blood which coagulates, forming fibrin and serum. The cells of the membrana granulosa proliferate and form a soft mass, which soon undergoes fatty degeneration and shows a yellow color. So, then, the Graafian follicle is replaced by a mass of fibrin, degenerated bloodcells, with coloring matter from them and by degenerated epithelial cells. This mass is called the *corpus luteum*, and is succeeded by a mass of cicatricial tissue.

MAMMARY GLAND.

What is the structure of the mammary gland?

It is a compound racemose gland, the alveolar spaces of which, lined with cuboidal epithelium, open into fifteen or twenty excretory ducts, lined with cylindrical cells. Between the gland alveoli the spaces are filled with fibrous areolar tissue and adipose tissue, and contain numerous bloodvessels. When the gland is active there seems to be a marked increase in the number of gland alveoli, and the epithelial lining cells contain drops of fat.

THE CENTRAL NERVOUS SYSTEM.

SPINAL CORD.

Of what is the spinal cord composed?

Of *gray matter internally* and *white matter externally*. It is covered by a sheath of connective tissue (*pia mater*) containing numerous bloodvessels. The inner layer of this sheath is dense and fibrous, and the outer layer, sometimes called the *arachnoid*, is more delicate in structure and is non-vascular. Lining the vertebral canal is another dense fibrous layer called the *dura mater*. The cord is nearly divided into two hemispheres by an anterior and a posterior fissure, into both of which a fold of the pia mater projects. The hemispheres are united by a bridge composed anteriorly of white matter (*white commissure*) and posteriorly of gray matter (*gray commissure*). In the centre of the gray commissure is a small canal (*the central canal*), lined with cylindrical ciliated epithelium cells.

How is the gray matter of the cord arranged?

In the centre of each hemisphere it is collected into a crescentic-like mass with its long axis running antero-posteriorly. The two masses are connected by the gray commissure. The anterior cornua are rather thick and do not come to the surface of the cord. The posterior cornua are narrow and do come to the surface.

How is the white matter of the cord arranged?

By the passage of nerve roots to the cornua it is divided into three principal divisions: The *anterior*, *lateral*, and *posterior columns*.

What is the structure of the gray matter of the cord?

It contains, especially in the anterior cornua, a number of multipolar or ganglion cells, also peculiar branching cells called neuroglia or spider cells. Besides these cells it consists of interlacing nerve fibres

and branching processes of nerve cells. In the bases of the posterior cornua at their inner side, especially in the dorsal portion of the cord, is a collection of ganglion cells. This is called the *column of Clark.*

Of what is the white matter of the cord made up?

Of medullated nerve fibres running longitudinally with the long axis of the cord. These fibres are supported among the interlacing processes of the neuroglia cells, and by connective tissue passing in from the pia mater. In the apices of the posterior cornua these neuroglia cells are especially numerous. During life this spot has a gelatinous appearance and is called the *substantia gelatinosa of Rolando.*

What may be said of the blood supply of the cord?

Bloodvessels enter the cord from the pia mater and ramify in its substance, the capillary plexuses being more dense in the gray than in the white matter.

BRAIN.

Of what is the brain composed?

Of gray and white matter, arranged in a more complicated manner than in the spinal cord. The collections of gray matter are connected together by nerve fibres from the white substance. The gray matter is composed of ganglion cells and fine nerve fibres, supported by connective tissue. The white matter consists of fine, delicate, interlacing nerve fibres, supported by a delicate connective tissue similar to the neuroglia tissue of the cord.

Describe the cortex of the cerebrum.

It is composed of five layers. The first or superficial layer is principally connective tissue, with delicate interlacing nerve fibrils and a few small, scattered, round and branching nerve cells. The second layer is characterized by a great number of small pyramidal-shaped cells. The third layer, the broadest of all, contains numbers of large ganglion cells, pyramidal, fusiform, or multipolar, with their long axis perpendicular to the surface of the cortex. The fourth layer, much narrower than the last, consists of great numbers of round, branching, and irregular-shaped cells. The fifth layer contains medium-sized fusiform cells, with long tapering processes, and also contains a few small, irregular-shaped cells. In the third layer certain of the nerve fibres begin to take a course toward the white matter. While in the fourth and fifth layers they show as distinct bundles.

Describe the layers of the cerebellum.

The outer or molecular layer is composed of a delicate connective-tissue framework supporting fine nerve fibres and small fusiform and branching nerve cells. The middle or cellular layer is composed of a row of irregular-shaped branching cells (*Purkinje's cells*). The branching processes ramify in the outer layer while the axis-cylinder passes inward through the inner layer. The inner, or granular layer, contains great numbers of small, round cells. This layer merges gradually into the white central substance of the cerebellum.

Of what kind of tissue is the dura mater composed?

Of dense, fibrous tissue, with connective-tissue cells between the fibres, and contains numerous bloodvessels. Its inner surface is lined with a layer of endothelial cells.

What is the structure of the pia mater?

It is a thin membrane covered on its outer surface with a layer of endothelial cells. It is composed of connective tissue, and contains a very rich network of blood and lymph vessels.

THE EYE.

EYELID.

Of what is the eyelid proper composed?

Of a plate of connective tissue which toward its free border becomes very dense and firm. This portion is called the *tarsus* or *tarsal cartilage;* although it is not cartilaginous, but is composed of dense fibrous tissue.

How is the eyelid covered externally?

On the outside by skin, which is beset with delicate hairs and contains sweat-glands and sebaceous follicles. It passes over on to the edge of the lid and meets the mucous membrane. In this free edge of the lid are inserted the eyelashes, having deep follicles which are furnished with sebaceous glands.

How is the eyelid covered internally?

By a layer of mucous membrane which is reflected over from the eyeball. It is called the conjunctival mucous membrane, and consists of a loose fibrous structure containing elastic fibres and numerous round and branching cells. It is covered by stratified epithelium near the skin edge.

How are muscle fibres distributed to the eyelid?

Between the skin and tarsus are bundles of striated muscle (*musculus orbicularis palpebrarum*). Between the tarsus and conjunctival mucous membrane is a layer of smooth muscle cells.

What are the Meibomian glands?

They consist of vesicular alveoli, lined with cylindrical cells, and are arranged along and open into excretory ducts lined with laminated epithelium. They open upon the free edge of the lid.

Describe the accessory tear glands?

They are small, racemose glands opening on the surface of the eyeball near the line of the reflection of the conjunctiva.

EYEBALL.

Of what is the outer wall of the eyeball composed?

Of a dense, connective-tissue layer called the *sclera or sclerotic.* It is transparent at the outer segment of the eyeball and is here called the *cornea.* The point of union of the two portions is called the *sclero-corneal junction.*

What is the layer within the sclerotic?

It is a delicate vascular coat called the *choroid.* At the sclero-corneal junction this layer is thrown into numerous longitudinal folds called the *ciliary processes.* Extending from the ciliary processes is a perforated vascular curtain composed of connective tissue and muscular fibres called the *iris.* It is suspended behind the cornea and connected peripherally near the sclero-corneal junction with a connective-tissue structure called the *ligamentum pectinatum.*

Describe the ciliary muscle.

It is a flattened ring of smooth muscle fibre, passing backward from the ligamentum pectinatum, between the ciliary processes and sclerotic, to be attached posteriorly to the choroid.

What is the ciliary body?

The ciliary processes and muscle together form it.

What is the retina?

It is the innermost layer of the wall of the eyeball, and, beginning at the entrance of the optic nerve, spreads out over the choroid. The nerve elements extend about two-thirds of the way forward from the back of the eye and cease in a wavy line (*the ora serrata*). Certain cellular elements continue over the ciliary processes and are called *pars ciliaris retinæ.*

Describe the suspensory ligament.

It is a delicate fibrillated membrane attached on the one hand to a membrane covering the ciliary processes, and on the other to the capsule of the crystalline lens, which is suspended by it just behind the iris.

Describe the chambers of the eye.

Histologically, the eye is divided into an *anterior* and *posterior* chamber by the crystalline lens and suspensory ligament. The anterior chamber contains a homogeneous fluid called the *aqueous fluid*, and the posterior a gelatinous mass called the *vitreous* body. Ophthalmologists, however, call the portion between the cornea and the iris the *anterior chamber*, and that between the iris and crystalline lens the *posterior chamber*

Describe the structure of the vitreous body.

It is a gelatinous, ill-defined lamellar structure containing a variable number of ill-defined, granular cells. It is surrounded by a delicate membrane called the *hyaloid membrane.* It is connected posteriorly with the retina, from which it is difficult to differentiate. This membrane is thickened and fibrillated over the ciliary process, where it is called the *zonula ciliaris.* A prolongation of it forward goes to make up the suspensory ligament of the lens.

What is the structure of the sclera ?

It is made up of closely-woven fibrous tissue, between the fibres of which are scattered flattened cells, some of which may contain pigment. On its external surface delicate fibres are given off anteriorly to the subconjunctival tissue, posteriorly behind the muscle tendons they join to form the wall of a lymph sac (*capsule of Tenon*). On the inner wall fibres pass to the choroid coat, some of which help to form the outer wall of a lymph sac between the sclerotic and choroid, called on account of its color the *lamina fusca.* The opening for the entrance of the optic nerve in the posterior segment of the sclerotic is covered by a network of connective-tissue fibres called the *lamina cribrosa.*

Describe the cornea.

It is directly continuous with the sclerotic, but differs from it in that its fibres are clearer and more regularly arranged. Its free surfaces are covered with epithelium and its cellular elements are peculiar in form. It consists of five separate layers.

Describe the layers of the cornea.

First, the *anterior corneal epithelium* consists of a layer of stratified epithelium; next is a dense transparent membrane made up of closely-packed fibrillæ and called the *anterior basal membrane*, or *lamina elastica anterior*. The middle layer or *substantia propria corneæ* is composed of connective-tissue fibres made up of clear fibres. Lying upon this layer is a thin structureless membrane called the *membrana elastica propria*, or *membrane of Descemet*, which in its turn is covered by a simple layer of epithelium.

Describe the choroid coat.

It is composed of four indistinct layers. Its outer layer lies next to the *lamina fusca* of the sclerotic, forming the inner wall of the lymph sac, between the sclera and choroid, and is called the *lamina supra-choroidea*. This layer is made up of a series of connective-tissue membranes, containing delicate elastic fibres and irregular and branching pigmented cells. The next layer is composed of blood-vessels of the choroid and is called the *external vascular layer*, or the *layer of Haller*. Within this is a dense network of capillary blood-vessels forming the third coat and called the *chorio-capillaris*. Lastly, the inner layer of the choroid is composed of an extremely delicate, finely-striated membrane, the *lamina vitrea*, or *membrane of Bruch*.

Describe the iris.

It is a thin connective-tissue membrane perforated at its centre by an opening (*the pupil*), and consisting chiefly of interlacing connective-tissue fibres, and numbers of irregular and branching pigment cells. It contains numerous bloodvessels with thick walls, and near the pupillary opening are seen smooth muscle fibres circularly arranged (*sphincter pupillæ*). Radiating toward the periphery from this ring are other smooth muscle fibres (*dilator pupillæ*). The anterior surface is covered by a single layer of epithelial cells. The posterior surface is composed of a layer of densely pigmented, irregular, polyhedral cells forming the *uvea*.

Name the layers of the retina.

1—Membrana limitans interna.
2—Layer of nerve fibres.
3—Layer of nerve or ganglion cells.
4—Internal molecular layer.
5—Internal nuclear layer.
6—External molecular layer.

7—External nuclear layer.
8—Membrana limitans externa.
9—Layer of rods and cones.
10—Pigment layer.

Describe the limiting membranes.

They are perforated by numerous openings and are very delicate and homogeneous. They belong to the connective tissue of the retina.

From what is the layer of nerve fibres derived?

It is formed by the expansion of the optic nerve after it has passed through the coats of the eye. This layer is thicker in the posterior than in the anterior portion of the eye.

Describe the layer of nerve cells.

It is composed of large nerve cells resembling Purkinje's cells in the cerebellum. On one side they have an axis-cylinder, continuous with a nerve fibre, and on the other side branching processes which are lost in the other layers.

Of what is the inner moleculæ composed?

Of cells resembling the neuroglia of the gray matter of the brain.

What is the structure of the inner nuclear layer?

It is composed of bipolar cells having large nuclei.

What is the structure of the outer molecular layer?

It is thin, and composed of branching cells, the processes of which interlace.

What is the structure of the outer nuclear layer?

It is made up of a delicate network of nerve fibrils mixed with connective tissue. Its nuclei and cells are intimately connected with the layer of rods and cones.

Describe the layer of rods and cones.

The rods are the longer elements and are pointed where they join the nerve fibres of the external nuclear layer. The cones are shorter; connecting with nerve elements internally, they terminate externally in a pointed or rounded extremity.

Describe the cells of the pigment layer.

Seen on the surface they appear as large hexagonal-shaped cells, side by side, forming a layer over the ends of the rods of the preceding layer.

Describe the crystalline lens.

It is a transparent, double-convex body, made up of laminated fibres, and enclosed in a homogeneous elastic capsule. The suspensory ligament is firmly attached to its peripheral zone. The body of the lens, while transparent, is not structureless. Behind the anterior wall of the capsule there is a single layer of flattened, polygonal-shaped cells, which at the margin of the lens becomes elongated and passes into the lens fibres. These fibres are long and ribbon-shaped and are intimately cemented together. They have finely serrated edges and on cross section appear prismatic in shape. Many of the superficial lens fibres are nucleated, these fibres having been developed by an elongation of epithelial cells.

For a description of the ear and nose, see the volume on *Anatomy* of this series.

PATHOLOGY.

Of what does pathology treat?

Of the physiology of disease and of the changes in structure brought about by disease.

CHANGES IN THE BLOOD CIRCULATION.

What is hyperæmia?

It is a condition of a tissue containing more blood than normal.

What are the two general forms of hyperæmia?

Active and *passive.*

Upon what do these conditions depend?

Active hyperæmia, or congestion, depends upon an increased flow of blood *to* the part, while passive hyperæmia depends upon a decreased flow of blood *from* the part.

What is anæmia?

It is a condition in which there is less than the normal amount of blood in a tissue.

Upon what conditions does anæmia depend?

Either upon a general deficiency of blood throughout the body (*oligæmia*) or the diminution of blood supply to the affected part (*ischæmia*).

Describe the condition called œdema.

The lymph which bathes the tissues of the body is simply a transudation from the bloodvessels; normally this is carried off by the lymph channels. When this transudation is greater in amount than the lymph channels can carry off, it collects in the tissues, and the resulting condition is called œdema.

What are the terms applied to œdema of different parts of the body?

Hydrops, or *dropsy*, when the fluid collects in the greater cavities of the body.

Anasarca when beneath the integumentary structures.

Ascites when collected in the abdominal cavity, and *general dropsy* when the effusion is general throughout the body.

What is hemorrhage and how does it take place?

It is an escape of blood from the heart or bloodvessels and may take place by rupture (or rhexis) or by diapedesis.

How is hemorrhage by rupture produced?

Either by external injury, or the walls of a bloodvessel become so weakened by disease that the pressure of blood within is enough to rupture them.

Describe rupture by diapedesis.

There is no appreciable change in the vessel-wall, but it is supposed that through some change in nutrition the vessel-walls are weakened, and that the white-blood cells, partly by virtue of their amœboid motion, pass between the cells lining the vessel. The red-blood cells have no power of motion and are thought to be carried passively through the endothelial cement substance by minute currents of fluid which follow the white-blood cells.

What are the terms applied to the different forms of hemorrhage?

Petechiæ—very small hemorrhages.

Ecchymoses or *Suggillations*—larger, diffuse hemorrhages in the interstices of a tissue.

Hemorrhagic Infarction—a complete infiltration of a circumscribed portion of tissue with blood.

Hæmatoma—a circumscribed collection of blood in a tumor-like mass.

What are thrombi?

They are masses made up of different elements of the blood mixed in varying proportions. They are produced in the heart or vessels by the coagulation of blood incited by injury or disease. When lying against the wall of a vessel they are called *parietal thrombi*, and when entirely filling a vessel are called *obliterating thrombi*.

What changes occur in thrombi?

They may soften, break up and be carried into the circulation. They may degenerate, become infiltrated with lime salts, and are then called *phlebolites* or *vein stones;* or, they may organize and form new connective tissue.

What is an embolism?

It is a stoppage of a bloodvessel by some mass of material (larger than the lumen of the vessel) which has been carried along in larger vessels in the circulating blood. The obstructing mass is called an *embolus*.

Of what are emboli composed?

Emboli are formed most often from detached bits of thrombi. They may be formed of fragments of: heart valves, tumors, masses of bacteria, drops of fat from marrow of fractured bones, bubbles of air, etc.

If an embolus lodges in a terminal artery what occurs?

The affected region usually dies; there may be an extravasation of blood by diapedesis (*hemorrhagic infarction*), or the part is deprived of blood and nourishment and undergoes necrosis. The seat of trouble is light in color and is called a *white infarction.*

What is lymphorrhagia?

It is the condition occurring when a lymphatic vessel is ruptured and the contained lymph is effused into the surrounding tissue.

CHANGES IN THE COMPOSITION OF THE BLOOD.

Define the conditions hydræmia and anhydræmia.

Hydræmia is a condition in which the watery constituent of the blood is increased above the normal. Anhydræmia is directly opposite, the watery constituent is less than the normal amount.

What are the changes in blood in leucocytosis and leukæmia or leucocythæmia?

In the former there is simply a temporary increase in the number of white-blood cells, while in the latter there is a persistent, progressive, and enormous increase of the white-blood cells.

What are the changes in the blood in anæmia?

The red-blood cells may be diminished in number or deficient in hæmoglobin, or both conditions may be present. In pernicious anæmia numbers of spheroidal or irregular-shaped bodies are found, supposed to be distorted red-blood cells. These are called microcytes.

Describe melanæmia.

In this condition the blood contains irregular particles of black or brown pigment, sometimes free, at other times enclosed in the white-blood cells.

Name some of the foreign bodies found in the circulating blood.

Air, degenerated epithelial cells from vessel-walls, tumor cells, fragments of decomposing thrombi, bits of heart valves, fat (normally present in digestion and lactation), parasites, and bacteria.

DEGENERATIVE CHANGES IN TISSUE.

What is necrosis? Give some of its causes.

Necrosis is the death of a circumscribed portion of tissue, and may result from insufficient nutrition, mechanical injury, extreme degrees of heat or cold, bacterial products, or from the action of destructive chemicals.

What is the appearance of necrosed tissue microscopically?

It may show a mass of degenerated cells and cell detritus, or the tissue may be swollen, granular, and disintegrated. Finally the whole may form a mass of irregular granules with fat droplets, various forms of crystals, shreds of the more resistant tissues and bacteria mixed with them.

How is coagulation necrosis produced, and how is the tissue altered microscopically?

When the blood supply is cut off from a portion of tissue surrounded by or continuous with healthy tissue, this "cut-off" area is one of "coagulation necrosis," and a peculiar change takes place, in which the cells of the tissue are altered and appear under the microscope shining and translucent, diminished in size, sometimes altered in shape, and the nuclei have disappeared.

What is the meaning of the term cheesy degeneration?

It is a term applied to a form of tissue degeneration, similar to the degeneration in coagulation necrosis. In the form of degeneration specified as cheesy, however, the dead tissue loses its structural features completely and becomes converted into granular, albuminous, and fatty material, which may disintegrate and soften or may dry and become dense and firm, or may become infiltrated with lime salts.

What change takes place in parenchymatous degeneration or cloudy swelling?

The cells of organs or tissues that have undergone this change become swollen and so filled with albuminous granules that the original cell structure is entirely concealed. The gross specimen of such a degenerated tissue is of a dull-grayish appearance; it is swollen and less translucent than under normal conditions.

What is fatty degeneration?

The protoplasm of a cell becomes converted into fat, at first, as little drops which coalesce to form larger ones, until finally the cell-protoplasm may be entirely replaced by fat.

What is fatty infiltration?

It is a condition similar to fatty degeneration, and in many cases it is impossible to make a definite distinction between the two. In fatty infiltration, however, it is believed that the fat originates *between* the cells, and, accumulating there, causes a passive atrophy of the cell-protoplasm by pressure.

Describe amyloid degeneration.

This is a process (sometimes termed waxy or lardaceous degeneration) in which the basement substance of various forms of connective tissue, and especially of the walls of bloodvessels, becomes swollen and thickened by its conversion into a translucent, firm, glassy, colorless material, albuminous in character. This material on treatment with iodine changes to a mahogany color. It is not known whether the change is brought about by a transformation of the tissue, or whether it is an infiltration of the tissue by some abnormal material formed elsewhere and brought to it, or is derived from the blood.

What are corpora amylacea?

They are small, spheroidal, homogeneous, or lamellated bodies, which become of a bluish color when treated with iodine and sulphuric acid. They seem to have nothing to do with waxy degeneration, although they somewhat resemble its products.

Describe mucoid degeneration.

It may occur in cells or in intercellular substance. When occuring in cells the cell-protoplasm is transformed into a translucent semifluid material containing mucin. This material occupies more space than the cell-protoplasm, hence the cells are swollen.

What is colloid degeneration?

It closely resembles mucoid degeneration, chemically and morphologically. Often there is no definite microscopical distinction to be made between the two changes. Colloid material is firmer and more consistent than mucoid, and contains no mucin that can be precipitated by acetic acid.

What is hyaline degeneration?

It is the transformation of tissues into a transparent, glassy substance, resembling amyloid degeneration, but it does not give the micro-chemical reactions of that material.

What is the change in calcareous degeneration?

There is a deposition of larger and smaller granules of phosphate and carbonate of calcium in the intercellular substance of tissues.

Macroscopically these tissues are hard, brittle and of a whitish color. Under the microscope the granules appear dark by transmitted light, and white and glistening by reflected light.

Describe pigmentation.

Pigment present in the body under abnormal conditions may be formed in the body or introduced from without. It occurs as yellow, brown, black, or reddish granules, and is found in the cells or the intercellular substance. Usually the pigment is formed from the hæmoglobin of extravasated red-blood cells. Or, as in the pigmentation of lung tissue, it may be introduced from without the body by inhalation of particles of dust.

INFLAMMATION.

It is impossible to give an exact definition of the term inflammation, therefore the best that we can do is to confine ourselves to a consideration of the morbid changes to which this term is generally applied.

How may the changes occurring in inflammation be classified?

Vascular changes, *proliferative changes*, *degenerative changes*, and finally, *reparative changes*.

Describe the vascular changes of inflammation?

First, there is a dilatation of the arteries, veins and capillaries, with an increased rapidity of the blood current. Then, the blood current becoming slower, the white-blood cells accumulate in the veins and capillaries and stick to the vessel-walls. Then, by virtue of their amœboid movement, the white-blood cells work through the vessel-wall into the surrounding tissue. They are followed by the red-blood cells in smaller numbers and by the blood plasma.

What products, then, are found in tissue as the result of inflammation?

White-blood cells (which are here called *leucocytes*, or *pus cells*); red-blood cells, fibrin produced by the union of elements in blood plasma with white-blood cells; serum, the portion of the blood plasma left after the formation of fibrin. These different elements may occur in different proportions in different cases.

What are the effects of this process?

Heat, redness, swelling, and pain.

Describe the proliferative changes.

There is simply an increased growth or proliferation of connective-tissue cells.

What are the degenerative changes?

These changes are necrotic in character. There is a disintegration, solution and liquefaction of the entire tissue (cells and basement substance). Sometimes there is a coagulation of the exuded liquid and also of the disorganized tissue cells. Fatty degeneration is not uncommonly a secondary result of the vascular changes.

Describe the reparative changes.

When the circulating blood restores the vessel-walls to their normal state recovery begins. As soon as the vessel-walls perform their functions properly reabsorption takes place. The fluid portion of the exudate is absorbed by the lymphatics and bloodvessels, the cells, necrotic tissue, and coagulated exudations are liquefied and carried off in the same way. If these products lie on the surface they may be directly cast off. Finally, if the parts are vigorous and the area destroyed be not too great, there takes place a regeneration of the cells of which the affected part is composed. On the other hand, if the destruction of tissue is too great to be repaired by cell regeneration, then there is a production of new tissue (granulation and cicatricial).

Describe granulation tissue.

It is composed of cells, like white-blood cells, small, polygonal cells with large, single nuclei, epithelioid cells, branched or fusiform cells, bloodvessels and basement substance. The most important factor in this plastic process is the formation of new bloodvessels. They are numerous and at first thin walled, and are formed by a budding out from the original connective-tissue vessels, of solid sprouts of protoplasm, which become tunnelled, so that blood passes through them, and changed, so as to form a wall of endothelial cells. The basement substance is at first scanty, and is homogeneous or finely granular. As the tissue grows older it becomes more abundant, more dense, and fibrillated.

What is cicatricial tissue?

It is a modified granulation tissue, in which the basement substance has increased and become dense. The cells and new bloodvessels have disappeared and there has been formed a dense contracted area of fibrous connective tissue.

How are the different forms of inflammation most conveniently classified?

Into *exudative*, *productive*, *tubercular*, and *syphilitic inflammation*.

What are the changes in exudative inflammation?

The changes are vascular (as described heretofore), with the production of fibrin, serum and pus. In its simplest form there is little or no change in surrounding tissues. The trouble is transitory, simply interfering with the affected part for a short time. In the more severe forms there is an excessive production of pus cells, producing the so-called purulent or suppurating form of inflammation.

To what is suppurative inflammation usually due?

To the presence and growth in the tissue of bacteria (to be described hereafter). In this form of inflammation, in *connective tissue*, there is congestion, exudation of serum, emigration of white-blood cells, and death of portions of tissue. This dead tissue breaks down and becomes fluid. If this change takes place in the substance of a tissue, cavities called abscesses are formed which contain pus, serum and fragments of necrotic tissue. If occurring on a free surface these materials are cast off directly, leaving a cavity called an ulcer. In the viscera, beside these changes, the cells of the affected viscus degenerate and may break down.

What are the peculiar characteristics of some forms of exudative inflammation on mucous surfaces?

The inflammation may be characterized by an excessive production of fibrin forming a false membrane over the free surface of the tissue. When lying directly on the surface without implicating the superficial cells of the mucous membrane it can readily be stripped off, causing little or no hemorrhage. Such a membrane is called *croupous*. When the fibrin forming the membrane infiltrates and involves the epithelium, these cells pass into a condition of coagulation necrosis and form a part of the false membrane. Such a membrane is called *diphtheritic*, and when stripped off leaves a raw or bleeding surface.

What is productive inflammation?

It is a form of inflammation in which the product is new connective tissue, with little or no congestion and exudation. There are two forms—acute and chronic. In the acute form new connective-tissue *cells* are the only product. This form occurs most frequently in the peritoneum and pia mater. In the chronic form the product is new

connective tissue, with cells and basement substance in varying proportions.

To what changes does this form of inflammation give rise in different kinds of tissue?

In connective tissue it produces thickening and adhesions. In the viscera there is a growth of new tissue interfering with the functions of the organ, compressing the visceral cells and causing their degeneration.

In mucous membranes the stroma or corium is thickened either diffusely or in the form of polypoid growths, and the epithelial layer of cells may be thicker or thinner than normal. The mucous glands may be atrophied, hypertrophied or cystic, and their secretion increased or diminished.

To what is tubercular inflammation due?

To the influence of the presence and growth of the tubercle bacillus or to its products, or to both influences combined.

What is the nature of the inflammation?

It is of the exudative or productive type, or of both combined. There are the usual products of these two forms of inflammation and also the production of a new tissue called *tubercle tissue*.

Describe tubercle tissue.

It is composed of a basement substance forming a meshwork enclosing large polygonal cells and giant cells. It occurs in small spherical masses called *miliary tubercles*, or may occur as a diffuse infiltration. This form of tissue is of very low vitality and quickly dies, undergoing cheesy degeneration, followed sometimes by calcareous degeneration.

Describe syphilitic inflammation.

It is an inflammation caused by the poison of syphilis, probably due to the growth of some specific bacterium, the nature of which we are at present ignorant. The inflammation is of the exudative or productive type, or of both combined.

What is the type of tissue produced in this form of inflammation?

There is a production of new connective tissue, especially in the viscera, taking the form of an interstitial inflammation. Also there is produced, in connective tissue and in the viscera, a small round-cell and granulation tissue often in the form of circumscribed masses called *gummy tumors*. These masses when occurring in mucous membranes are called *mucous patches*.

TUMORS.

What are tumors?

They are new growths in the body composed of the same types of tissue as normally exist. They serve no definite purpose in the economy of life, and have a certain lawlessness of growth and life history.

In what shapes do they grow?

They may be *nodular*, *tuberous*, *polypoid*, *fungoid*, *papillary*, etc.

How do tumors grow?

Either by an increase of internal cell elements (*central growth*) or by growth and increase of cells at their periphery (*peripheral growth*).

How are tumors disseminated by metastasis?

The tumor cells may get into the blood or lymph vessels and be transported to some other part of the body, finally lodging and forming an embolus in some vessel. These cells may then proliferate and grow, thus forming a so-called *metastasis* or *metastatic tumor*.

How are tumors diagnosed?

By the general appearance and arrangement of their structural elements, and not by any peculiar or typical cell.

What are the features of a malignant tumor?

Malignant tumors invade adjacent tissues by peripheral growth, and are apt to recur after removal. Sooner or later they form metastases, and lastly they interfere in a marked way with the nutrition of the body and produce a condition known as *cachexia*.

In what way do the benign tumors differ from the malignant tumors?

As a rule, benign tumors grow slower and produce none of the above changes. Of course, so-called benign tumors may be serious in effect, if, through their position, they interfere with any of the vital functions of the body.

What are the causes of tumors?

Mechanical influences, heredity, and *possibly* bacteria. The theory of the embryonal origin of tumors seems at present the most satisfactory. This theory is that certain embryonal cells of various kinds do not undergo their normal changes, or that they become displaced, and thus act as a starting point for the growth of the tumor. Later in life these cells may start to grow unrestrained by the influences that control normal cells. Just what incites these cells to suddenly

become active after having lain dormant for possibly many years, is not well understood.

How are tumors classified?

According to the physiological type of tissue that they resemble, as per the following table:

HISTOID OR CONNECTIVE-TISSUE TUMORS.

Physiological Type.	*Tumors.*
Fibrillar connective tissue.	Fibroma.
Mucous tissue.	Myxoma.
Embryonal connective tissue.	Sarcoma.
Endothelial cells.	Endothelioma.
Adipose tissue.	Lipoma.
Cartilage	Chondroma.
Bone.	Osteoma.
Neuroglia cells.	Glioma.
Lymphoid tissue.	Lymphoma.

MUSCLE-TISSUE TUMORS OR MYOMATA.

Physiological Type.	*Tumors.*
Smooth-muscle tissue.	Leiomyoma.
Striated-muscle tissue.	Rhabdomyoma.

VASCULAR-TISSUE TUMORS OR ANGIOMATA.

Physiological Type.	*Tumors.*
Bloodvessels.	Angioma.
Lymphatic vessels.	Lymphangioma.

EPITHELIAL TUMORS.

Physiological Type.	*Tumors.*
Nerve tissue.	Neuroma.
Skin and mucous membrane.	Papilloma.
Glands.	Adenoma.
Various forms of epithelial cells and associated tissue.	Carcinoma.

HISTOID OR CONNECTIVE-TISSUE TUMORS.

What is the structure of fibromata?

They are composed of fibrillar connective tissue. Some are made up of this form of tissue exclusively, while others, in addition, contain many various-shaped cells (flattened cells, spindle-shaped cells, etc.).

They may contain many or few bloodvessels. These tumors are classed as benign.

What are the characteristics of myxomata?

In structure they resemble mucous tissue. Branching cells with a relatively large amount of intercellular substance. This intercellular substance contains mucin. These tumors are benign but seldom occur as pure myxomata, usually combining with fibrous or fat tissue to form fibro- or lipo-myxomata.

What form of tissue do the sarcomata resemble and into what varieties are they classified?

They resemble embryonal tissue, being made up of spheroidal or of spindle-shaped cells with a small amount of fibrillar intercellular substance. They are classified according to the shape and size of their predominating cell elements, and are malignant. The varieties usually referred to are the *large and small round-celled*, *the large and small spindle celled*, *the giant-celled sarcomata* and also *the melano-sarcoma*. Combinations of sarcoma tissue with that of other forms of tumor may give rise to various compound tumors to be described later.

What is the structure of the large- and of the small-celled sarcomata?

The small-celled form is made up of cells resembling lymph cells, and of about the same size. There may be much or little intercellular substance. The cells may be irregularly disposed or may be arranged in indistinct alveoli. In the large-celled variety the cells are of various sizes, but the majority of the cells are larger than those of the previous variety. Both forms are, as a rule, very vascular, and the small-celled variety is the more malignant of the two.

Describe the spindle-celled sarcomata.

The spindle-shaped cells may be large or small. There may be very little intercellular substance, or it may be so abundant as to resemble fibrous tissue, thus forming a fibro-sarcoma. These forms are as a rule less malignant than the round-celled varieties.

What are the peculiar features of a melano-sarcoma?

Large and small particles of a blackish or brownish pigment are found irregularly distributed in the cells, less often in the intercellular substance. The cell structure is most often of the spindle-shaped variety, although other-shaped cells may be found.

What is the structure of a myeloid or giant-celled sarcoma?

The principal bulk of the tumor is made up of either the round or spindle-shaped cells. Mixed with these irregularly are found large multi-nucleated cells or giant cells. They occur usually with bone.

What is an osteo-sarcoma?

Tumors are either of the round or spindle celled variety, in which are found irregular masses of newly-formed bone.

Describe an angio-sarcoma.

In some sarcomata the bloodvessels form such a prominent feature, that is, they are so numerous and their lumina so large, that the tumors contain a large amount of blood. The sarcoma cells also are apt to be arranged in strings, each having a bloodvessel for its centre.

What is an alveolar sarcoma?

In this form the intercellular substance is arranged as a net, the meshes of which resemble alveoli. The sarcoma cells are attached to the sides of the alveolus as well as lie free in its cavity. Fine trabeculæ from the alveolar walls run between the cells, and by this feature we are usually able to differentiate between this form of sarcoma and carcinoma. Sometimes, however, this is impossible.

What are the combinations of sarcoma with other tissue?

With *myxoma* forming *myxo-sarcoma.*
With *adenoma* forming *adeno-sarcoma.*
With *fat tissue* forming *lipo-sarcoma.*
With *muscle tissue* forming *myo-sarcoma.*

What is the structure of the endotheliomata?

These tumors originate from endothelium by cell proliferation, and are often very difficult to differentiate from sarcoma and from carcinoma. The individual cells may resemble normal endothelium, or may be large, thick and irregular in shape, or may be cuboidal.

Of what are the lipomata composed?

Of fat tissue, and may contain much or little connective tissue. They are benign.

What is the appearance of a section of a chondroma?

It resembles cartilage, but the cells are not as uniform in size and shape. Small growths on the surfaces of normal cartilages are called *enchondroses.*

What is an osteoma?

It is a tumor of the formation of true bone in an abnormal place. When projecting from the free surface of a bone such a new growth is called an *exostosis*.

What are the constituent parts of a glioma?

Delicate cells having numerous branching processes or filaments. Also a greater or less number of small, round cells having large nuclei. Glioma tissue is apt to be mixed with other tumors, *e. g.*, glio-sarcoma.

What are lymphomata?

They are enlarged lymphatic glands whose tissue is practically lymphoid tissue.

MUSCLE TUMORS OR MYOMATA.

Of what are the myomata composed?

Of tissue resembling the physiological types of muscle tissue, the smooth and the striated. The leiomyomata or smooth-muscle variety are usually associated with the uterus. The rhabdomyomata or striated-muscle variety often occur with sarcomata.

VASCULAR-TISSUE TUMOR OR ANGIOMATA.

What are angiomata?

They are tumors made up of newly-formed bloodvessels. One form is described as being made up largely of capillary bloodvessels imbedded in connective tissue. The so-called strawberry marks or vascular nævi are examples of this variety.

The second form consists of a series of irregular-shaped intercommunicating cavities of varying sizes. These cavities are lined with endothelium, and are surrounded by a variable quantity of connective tissue.

What is a lymphangioma?

It is a tumor consisting simply of dilated lymph channels.

EPITHELIAL TUMORS.

What is a neuroma?

It is a tumor composed of newly-formed nerve tissue, but it is very rare. Tumors developed in the connective tissue of nerve bundles often receive this name, but usually they are growths of fibrous tissue or fibromata, and are sometimes called false neuromata. They may or may not be painful, and not infrequently they form at the cut ends of nerves after amputation.

What is a papilloma?

It is a tumor formed of enlarged papilli covered by epithelium. It may be situated either on a skin or mucous membrane surface.

Describe an adenoma.

It is a tumor formed by a reproduction of typical gland tissue. The structure of the cellular elements and their arrangement into alveoli and ducts vary widely. The irregularities of their growth often lead to a stoppage of the ducts and alveoli and formation of cysts.

Of what is a carcinoma composed?

It is a malignant tumor composed of a connective-tissue stroma forming more or less well-defined communicating spaces or alveoli, in which lie various-shaped epithelial cells. The cells in these alveolar spaces are not attached to their walls, and there is no fibrillated intercellular substance between the cells as in sarcoma tissue.

Into what varieties may the various forms of carcinomata be classified?

Gland-celled carcinoma, *cylindrical-celled carcinoma*, *flat-celled carcinoma* or *epithelioma*, *colloid carcinoma*, *melano-carcinoma* and *carcinoma myxomatoides*.

Describe a gland-celled carcinoma.

It is characterized by its alveolar structure and by the absence of any special characteristic shape to its cells, which may be fusiform, polyhedral, cuboidal or spheroidal. The tumor may be hard or soft according to the relative amount of fibrous stroma present. If the fibrous tissue is abundant the tumor is hard and firm (*scirrhus carcinoma*). If scanty in amount the tumor is soft (*medullary cancer* or *carcinoma molle*).

What is a cylindrical-celled carcinoma?

It is made up like the preceding form, with the exception that a greater or less number of the cancer cells are cylindrical in shape.

What are the peculiarities of epitheliomata?

They usually occur on the skin or mucous membranes. The cells resemble those normally existing in these tissues, and have a similar life history. In some of the tumors of this variety the flattened cells are often packed about a central point concentrically. These are called *bird-nest bodies* or *epithelial pearls*.

What is a colloid carcinoma?

It is a carcinoma, the cells of which have become infiltrated with

a peculiar translucent material called *colloid*. It may not be confined to the cells, but may partly fill the alveolar spaces of the tumor.

What is a melano-carcinoma?

It is a carcinoma containing granules of a black or brown pigment in varying quantities.

Describe a carcinoma myxomatoides.

Cysts of different sizes containing a mucous fluid may be formed in a carcinoma by means of the mucous softening of the cells. To such a cancer this term is often applied. It should, however, be applied to those carcinomata in which the stroma is composed of mucous tissue.

MIXED TUMORS.

What are the mixed tumors?

They are formed by various combinations of the different types of tumors, and in naming them the name of the more important type of tumor present is used as the substantive, and that of the less important type as the qualifying term.

What are the teratoma?

They are complex, congenital tumors, of different forms of tissue, formed most often at the lower end of the spine, about the head and neck, and the organs of generation. Some of them probably arise by an inclusion of portions of another fœtus.

CYSTS.

Into what classes may cysts be divided?

I. *Cysts which develop in pre-existing cavities.*

II. *Cysts which originate independently as the result of pathological changes.*

Name and describe those belonging to the first class.

Retention and *exudation cysts.*

The former being formed by the accumulation in glands or excretory ducts of the more or less altered secretion of the gland, *e. g.*, comedones, ranulæ ovula Nabothi, milk cysts, serous cysts of ovaries, Fallopian tubes, and uriniferous tubules.

The serous cysts occur as the result of chronic inflammatory processes in the lymph spaces or serous sacs, *e. g.*, ganglia, hydrocele, etc.

What cysts may originate from pathological changes?

(*a*) Cysts formed by the softening and disintegration of tissue; at first these cysts have no well-defined wall, but later a definite wall

may be formed. The contents of such a cyst are made up of the detritus of the decomposed tissue.

(*b*) Cysts whose wall is formed by inflammatory exudation around foreign bodies, parasites, extravasated blood, etc.

(*c*) Cysts formed by a new growth of tissue, in the spaces of which various kinds of fluid accumulate. The spaces may or may not be lined with epithelium. Some of the compound ovarian cysts are examples of this type.

(*d*) Congenital cysts, their mode of origin is not well understood. Dermoid cysts of the subcutaneous tissue and of the ovary are of this class. They contain a greasy material mixed with elements of the skin, hair, teeth, nails, etc.

RESPIRATORY SYSTEM.

LARYNX.

What are the changes in an acute catarrhal laryngitis?

The microscopical changes are not marked. There is an increased desquamation of the superficial cells and an increased production of the deeper cells. A few pus cells are also found. The mucous membrane is at first congested, swollen and dry. Soon the mucous glands, becoming more active, produce an increased amount of mucus.

How is the larynx affected in chronic catarrhal laryngitis?

The mucous surface is coated with muco-pus; the stroma is infiltrated with cells and is thickened or thinned, or it may be necrotic or ulcerated. The mucous glands are swollen and prominent.

What is croupous laryngitis?

It is an exudative inflammation in which the mucous membrane is covered with fibrin and pus. These elements infiltrate the stroma, and cause coagulation necrosis of the epithelial cells.

What are the changes in syphilitic and in tubercular laryngitis?

The surface of the mucous membrane may be covered with muco-pus. Small ulcers are often seen. The products of inflammation are the same as those described under syphilitic and tubercular inflammation.

What change takes place in œdema of the glottis?

The tissues are infiltrated with a serous exudation, and become enormously swollen.

What tumors may be present in the larynx?

Retention cysts, papillomata of fibrous connective tissue, fibromata, lipomata, myxomata, angiomata, chondromata, sarcomata and *carcinomata.*

PLEURA.

What are the different varieties of pleurisy?

Pleurisy with the production of *fibrin.*
Pleurisy with the production of *fibrin* and *serum.*
Pleurisy with the production of *fibrin, serum* and *pus.*
Chronic pleurisy with the formation of adhesions.
Tubercular pleurisy.

What are the changes in the first three forms?

The form of inflammation is of the exudative type, and gives the same changes as described with that form of inflammation. There may also be a proliferation of the connective-tissue cells.

Describe chronic pleurisy with the formation of adhesions.

It may follow after the preceding types, or tubercular pleurisy, or may occur by itself. It resembles the productive form of inflammation. There is also an increase in the number of bloodvessels.

What are the changes in tubercular pleurisy?

They are the same as described under tubercular inflammation.

What tumors have been found occurring in the pleura?

Fibromata, lipomata, carcinomata and *sarcomata.* The two latter types usually occurring as metastatic growths.

BRONCHI.

What are the changes in an acute catarrhal bronchitis?

The changes are those found in a slight exudative inflammation. The only lesions produced are, an increased amount of mucus, the infiltration of the stroma with a few pus cells, and a general congestion of the mucous membrane.

What are the lesions of a chronic catarrhal bronchitis?

The mucous membrane may be little changed or may be congested. The epithelium may be deformed and desquamated, and there may be a production of cells in the deeper layers. The smaller bronchi may contain mucus and pus. As a rule the microscopical changes seem to be very slight when compared with the marked symptoms that may be given with the trouble.

What products are found in the bronchi in a case of acute croupous bronchitis?

Masses of fibrin, pus and desquamated epithelium. Sometimes the stroma of the mucous membrane is infiltrated with fibrin and pus.

What is the product of a chronic croupous bronchitis?

There is an exudation of a large amount of fibrin, which coagulates in the form of a cast of the bronchi affected. After a time these casts are expectorated. Microscopically the wall of the bronchus is little altered.

What is a bronchiectasia?

It is a dilatation of a bronchus and may be fusiform, sacculated or cylindrical.

What new growths are found in the bronchi?

The walls may become ossified. Lipomata have been found. Carcinomata and sarcomata rarely occur here as primary growths; usually they are secondary.

LUNGS.

What are the two kinds of emphysema?

Interlobular and *vesicular*.

What are the changes in an interlobular emphysema?

Some of the air spaces are ruptured, and the air escapes into the interstitial tissue of the lung. If the pulmonary pleura is ruptured, air escapes into the pleural cavity (*pneumo-thorax*).

What changes are observed in the lung tissue in a case of vesicular emphysema?

Both lungs are increased in size. There may be pleuritic adhesions. The muscular portion of the wall of the bronchi may be thickened or the entire wall thickened and infiltrated with cells. The cells lining the air spaces are increased in size and number. The walls of the air spaces may be thickened or the air spaces may be dilated, their walls thinned and perforated with small holes which, later, may become larger.

What are the changes in atelectasis?

If due to congenital causes there is not much change from the appearance presented by fœtal lung. If this part of the lung remains unaërated the affected area becomes hard and firm. If the atelectasis is due to a plugging of one or more bronchi with pus, etc., or to compression or stenosis, the walls of the air spaces collapse. If the

obstruction is removed soon, the air spaces become inflated and normal. But if the collapse of the walls of the air spaces persists, then inflammatory changes of the exudative type are set up. New tissue may be formed and the affected part become solid.

How are the inflammations of the lung classified?

Acute lobar pneumonia.
Broncho-pneumonia.
Secondary and *complicating pneumonia.*
Pneumonia of heart disease.
Interstitial pneumonia.
Tubercular pneumonia.
Syphilitic pneumonia.

Describe the changes occurring in acute lobar pneumonia.

There is a growth of pathogenic bacteria, to be described later. The inflammation is purely of the exudative type. The course of the disease is divided into three stages. First, the stage of congestion, in which the microscopical changes are slight. Second, the stage of red hepatization, in which the air spaces and bronchi are filled with the products of the exudative inflammation, viz.: Fibrin, serum, pus, red-blood cells and a few epithelial cells. Third, the stage of gray hepatization, in which the red-blood cells lose their color, the various exudation products begin to degenerate, soften, and break down. A portion of this degenerated material is expectorated, the rest is absorbed and carried away by the lymphatics and bloodvessels. In this way the air spaces are cleared up, but in some of them occasionally there is a formation of new connective tissue which seems to be permanent.

What is the character of the lesion of broncho-pneumonia?

The change begins in the walls of the bronchi. They are infiltrated with new cells, this infiltration extending to adjacent air spaces and not to those in which the bronchi terminate. The affected air spaces become filled with pus and epithelium. In the gross specimen there are seen patches of solidification about the affected bronchi, but between these solidified portions the air spaces may still be aërated. The change may proceed until the affected portion of the lung becomes entirely solid by the extension of the inflammatory process and by the union of the masses of solidification. The bronchi may be filled with pus, but the first change is the thickening of the walls of the bronchi. Occasionally the infiltration of the walls of the air spaces and bronchi

with new cells remains permanent. Such a case runs a very chronic course and is called a *persisting broncho-pneumonia.*

What are the changes in secondary and complicating pneumonia?

The inflammation usually occurs with lesions of the brain and spinal cord, pyæmia, continued fevers, surgical operations and with some of the infectious diseases. The lung may be congested and mottled with irregular patches of red and gray hepatization and the air spaces filled with fibrin and pus. Or the lesion may follow the same type of inflammation as a broncho-pneumonia.

What are the lesions in a case of pneumonia of heart disease?

The capillaries in the walls of the air spaces are dilated and appear to be increased in length so that they are tortuous in their course and often project into the air spaces. The walls of the air spaces are thickened. There is a formation of black or brown pigment granules, which may be deposited in the walls of, or in the new cells formed in, the air spaces. In these spaces, also, numbers of leucocytes are usually seen.

What are the changes in an interstitial pneumonia?

It usually follows a broncho-pneumonia or a chronic bronchitis, or arises from the inhalation of dust. There is an increase of connective tissue between the lobules and air spaces which may compress or even obliterate these spaces. The walls of the bronchi are the seat of a chronic catarrhal inflammation.

Describe tubercular pneumonia.

The classification of the forms of tubercular pneumonia seems best made upon the basis of their clinical history. The cases may be divided into *acute, sub-acute* and *chronic miliary tuberculosis, acute* and *chronic phthisis.*

What are the lesions of acute miliary tuberculosis?

In this form, which is generally accompanied by a general tubercular infection, there is a formation of miliary tubercles scattered irregularly throughout the lung tissue. These tubercles may grow in the walls of the air spaces or in the walls of the bronchi, or in the pleura. They are composed of tubercle tissue and vary widely in appearance. They may have become entirely cheesy, or only cheesy at the centre, or may not have degenerated at all. Tubercle bacilli can usually be demonstrated in them. There is a catarrhal bronchitis present, and the air spaces near the affected parts may contain epithelium, pus and fibrin.

What are the changes in the sub-acute and chronic forms of miliary tuberculosis?

In the *former* the changes are similar to those in acute miliary tuberculosis, but are confined to the apices of the lungs. The patient may recover, or the lesion may pass into the chronic form of miliary tuberculosis and extend slowly until a large part of the lungs is involved. In the *latter*, beside the growth of miliary tubercles, the walls of the bronchi may be inflamed and may become necrotic and destroyed in places. Bronchiectasiæ may form and there may be an interstitial pneumonia with a thickening of the pleura.

Describe the lesions found with acute phthisis.

This is an acute tubercular process, but beside the formation of products due to this form of inflammation there are other changes similar to those occurring in a broncho-pneumonia, with a general consolidation of lung tissue and a filling of the air spaces with epithelium, fibrin and pus. Bronchiectasiæ may be formed.

What are the changes in chronic phthisis?

The changes are the same as in acute phthisis, but the trouble runs a long course. The air spaces may be filled with fibrin, pus and epithelium in varying proportions and in various stages of degeneration, or may be filled with new connective tissue. Various nodules are found and these nodular portions may be composed of miliary tubercles, in the air spaces or about the bronchi, or they may be made up of cheesy material exclusively. The bronchi are the seat of a catarrhal inflammation and may be dilated, the dilatations being either fusiform or sacculated. Tubercle and granulation tissue may be present in the walls of the bronchi. There may be areas of coagulation necrosis which may undergo cheesy degeneration. Sometimes all active processes stop and the tubercular tissue be changed and converted into new connective tissue.

What is the form of inflammation in syphilitic pneumonia?

There is an interstitial inflammation which renders the walls of the air spaces thicker; these spaces may be compressed or obliterated by this new tissue. The inflammation may be confined to the walls of the air spaces or it may be diffuse. Obliterating endarteritis often accompanies this form of pneumonia.

What forms of tumors have been found in the lung?

Dermoid cysts, *fibromata*, *enchondromata*, *osteomata*, *sarcomata* and *carcinomata*.

The two latter, however, usually occurring as secondary or metastatic growths.

THE ALIMENTARY TRACT.

MOUTH, TONGUE, PHARYNX, ŒSOPHAGUS.

What different forms of inflammation are found in the mouth?

Among others, *catarrhal*, *croupous*, *tubercular*, and *syphilitic* stomatitis. The lesions are the same as those produced by the same types of inflammation elsewhere.

What is stomatitis ulcerosa?

It is a form of stomatitis beginning at the margins of the gums. They are swollen and covered with grayish matter composed of detritus and bacteria. Destruction of tissue follows and may extend from the gums to the lips, cheeks and tongue.

The teeth may fall out and there may even be necrosis of the jaws.

What is noma?

It is gangrene of the mucous membrane of the cheeks. The process extends in all directions and may produce perforations.

What tumors are found in the mouth?

Adenomata, *papillomata* and *carcinomata*.

Angiomata, *fibromata*, *lipomata* and *enchondromata*, have been found in the lips.

What is macroglossia?

It is a hypertrophy of the tongue, usually congenital.

Name and describe the inflammations of the tongue.

Superficial glossitis, the acute form presenting no marked lesion, and the chronic form resulting in an increased production of epithelium and a hypertrophy of the papillæ of the tongue.

Parenchymatous glossitis in which the muscular and connective-tissue portions are congested and infiltrated with serum and pus. This may result in the formation of an abscess.

Syphilitic and *tubercular glossitis* showing changes found in these forms of inflammation.

Name the tumors found in the tongue.

Cysts or *ranulæ* formed by a dilatation of the ducts of the glands under the tongue. *Angiomata*, *lipomata*, *fibromata*, *sarcomata* and *carcinomata*.

What are the inflammations of the pharynx?

Catarrhal pharyngitis, croupous pharyngitis and *submucous pharyngitis.* The first two forms of inflammation give the changes common to its own variety as described before. The submucous pharyngitis is an exudative inflammation affecting the submucous coat of the pharynx and may result in the formation of an abscess. Ulceration may occur in the pharynx from catarrhal or syphilitic inflammation.

What tumors have been found in the pharynx?

Fibromata, carcinomata, adenomata and *sarcomata.*

What changes may take place in the œsophagus?

There may be ulceration from pressure of foreign bodies etc. There may be cylindrical or sacculated dilatation, or there may be stenosis from injury or from new growths.

What forms of inflammation have been observed in the œsophagus?

Catarrhal and also *croupous inflammation,* giving the same changes as regularly occur with these forms of inflammation.

What tumors have been found in the œsophagus?

Cysts, papillomata, lipomata, myomata of smooth muscle, carcinomata and *adenomata.*

STOMACH AND INTESTINES.

What are the different forms of inflammation of the stomach?

Acute and chronic catarrhal gastritis, croupous gastritis and *suppurative* or *phlegmonous gastritis.*

What changes are produced in the first two forms?

In acute catarrhal gastritis the structural changes in the mucous membrane are very slight. The mucous membrane is covered with mucus and there may be a very slight exudative inflammation in it. In the chronic form there is a thick layer of mucus coating the mucous membrane. The wall of the stomach may be thickened or thinned and the stomach may be of normal size or dilated, or smaller than normal. The cells lining the gastric tubules are degenerated and may be broken down, the tubules are atrophied, or may be dilated into cysts. The connective tissue between the tubules is infiltrated with cells.

Give the lesions associated with the two latter forms of gastritis.

The croupous form is rare and gives the same changes in structure of the affected part as the same form of inflammation does elsewhere. In

the phlegmonous form there are circumscribed collections of pus formed in the connective-tissue coat of the stomach and these may produce perforations.

The mucous membrane of the stomach may also be inflamed or destroyed by the action of poisons or caustics which may have been swallowed.

What are the changes with chronic ulcer of the stomach?

It is supposed that a circumscribed portion of the mucous membrane of the stomach is deprived of blood, and that the nutrition of the affected part is so disturbed that the gastric fluid attacks and destroys it. There then appears a clean-cut hole in the mucous membrane, larger than in the layers lying under it.

What other changes may take place in the stomach?

There may be calcareous degeneration of the stomach walls, or waxy degeneration of the bloodvessels of the gastric mucous membrane. The stomach may be dilated or may be the seat of hemorrhages from various causes.

What tumors are described as occurring in the stomach?

Papillomata, *myomata*, *sarcomata*, *adenomata* and *carcinomata*.

What inflammations are common to the small intestine?

Acute catarrhal, *chronic catarrhal*, *croupous* and *suppurative inflammation*, giving about the same changes as have been described with the corresponding inflammation of the stomach.

What changes may occur in the solitary and agminated glands of the small intestine?

They may be swollen in cases of infectious disease and may be the seat of abscesses. They may be swollen on account of any of the different inflammations of the intestine. They also may be the seat of tubercular inflammation.

What forms of inflammation are found in the large intestine?

In the colon there may be an *acute* or *chronic catarrhal colitis*, or a *croupous colitis*. The same forms are common to the rectum. Each form gives the changes in the structure of the mucous membrane common to its own variety. The cæcum may be the seat of a catarrhal inflammation. In the vermiform appendix, the most frequent form of inflammation is a suppurative one.

What tumors may develop in the intestine?

Myomata, *lipomata* and *carcinomata*.

PERITONEUM.

Name the different forms of inflammation of the peritoneum.

Acute and *chronic peritonitis*, and *tubercular peritonitis*. If the greater part of the peritoneum is inflamed it is called a *general peritonitis*, if only a circumscribed part is affected then it is called a *local peritonitis*.

What are the varieties of acute peritonitis?

Cellular and *exudative*.

In the former variety there is a marked congestion. Microscopically there is a great increase in the size and number of the endothelial cells covering the peritoneum. There is no production of serum, fibrin and pus. In the exudative type there are present the changes found with exudative inflammations elsewhere, viz.: serum, fibrin and pus. There is an increased growth of endothelial cells which may form adhesions.

What are the varieties of chronic peritonitis?

Cellular peritonitis, *peritonitis with adhesions*, *chronic peritonitis with thickening* of the peritoneum, and *chronic peritonitis* with the production of fibrin, serum and pus.

What are the minute changes in the first two forms of chronic peritonitis?

In the first form the surface of the peritoneum is covered with cells of different shapes, which appear to have been derived from the endothelial and connective-tissue cells which make up the peritoneum. The second form seems to be this process continued until adhesions are formed.

Give the minute changes in the last two forms of peritonitis.

In the variety known as chronic peritonitis *with thickening*, the most noticeable feature is the thickening of the peritoneum. The outer part of the thickened portion consists of fibrous connective tissue and the inner layers of granulation tissue. The peritoneum may be an inch thick. The peritoneal cavity may contain clear or purulent serum. In the last form of chronic peritonitis there is a production of fibrin, serum and pus. The different parts may be matted together with the fibrin.

What are the changes in tubercular peritonitis?

They are the same as are common to all tubercular inflammations. The tubercular growth may occur as miliary tubercles or as diffuse infiltration. There may also be a production of serum, fibrin and pus in varying proportions.

What are the tumors occurring in the peritoneum?

Fibromata, lipomata, angio-sarcomata, carcinomata, sarcomata and *endotheliomata.*

LIVER.

What degenerative changes may take place in the liver?

Parenchymatous degeneration, fatty degeneration, fatty infiltration and *amyloid degeneration. Pigmentation* may occur as a result of malarial poisoning.

What affection of the liver is characterized by an extreme degeneration of the liver cells?

Acute yellow atrophy. The liver decreases rapidly in size. The cells become granular and fatty and soon break down into an indistinguishable mass in which may be seen fatdrops, pigment granules, red and yellow crystals, and amorphous debris.

What disturbances of circulation may occur in the liver?

There may be an anæmia, either general or partial, due either to a general anæmia or to a shutting off of blood supply from different parts of the liver by pressure. Also a hyperæmia which may be acute or passive. The acute process may be due to high living, excessive heat, suppression of menses, etc. The passive process is due to obstruction of the blood current in the hepatic veins.

Valvular disease of the heart is the most common cause of passive congestion of the liver.

What are the minute changes produced by a chronic hyperæmia?

In these cases the gross appearance of a section of the liver presents a mottled appearance, hence the name "*nutmeg liver*" is applied to this class of cases. As the congestion affects the hepatic veins the central veins of each hepatic lobule are dilated, this dilatation extends to the capillaries opening into the central veins. The liver cells between the swollen capillaries atrophy and become degenerated on account of pressure. The change of structure develops from the centre toward the periphery of each lobule, and there is a zone between the degenerated and healthy area that contains numerous leucocytes.

Name the different varieties of inflammation of the liver?

1. *Acute hepatitis* (*Abscess of liver*).
2. *Chronic interstitial hepatitis* (*cirrhosis*).
3. *Syphilitic hepatitis.*
4. *Tubercular hepatitis.*

Describe acute hepatitis.

It is a suppurative inflammation with the production of immense numbers of pus-cells in circumscribed areas. The abscesses formed are small but may coalesce, forming larger ones. The exciting cause may be the pressure of tumors, or injury, or the presence of bacteria.

What are the changes in cirrhosis of the liver?

It is a productive inflammation. There is an increased growth of connective tissue especially along Glisson's capsule between the hepatic lobules. There may be an increased growth of connective tissue between the cells composing the lobules, and also there may be numerous leucocytes in the bloodvessels. Cylindrical ducts are frequently found in the new connective tissue which resemble bile ducts. The hepatic lobules are compressed and there may be an amyloid or fatty degeneration of the liver cells. The most common secondary change is an ascites. The hemorrhoidal and vesical as well as the cutaneous veins about the umbilicus are frequently dilated. The spleen is frequently enlarged, and the stomach and intestines are sometimes the seat of hemorrhages.

What are the changes in syphilitic hepatitis?

The growth of new connective tissue may be more diffuse, or may appear the same as in the preceding form. In some cases small gummata are scattered through the liver.

Describe tubercular hepatitis.

This inflammation follows the same general type as do other tubercular processes, and may occur as miliary tubercles or as larger nodules. These foci of inflammation undergo the same degenerative changes as other tubercular inflammations. The affection is usually secondary and may be associated with a cirrhosis.

What tumors have been found in the liver?

Fibromata, *lipomata*, *adenomata*, *angiomata* *sarcomata* and *carcinomata*.

PANCREAS.

What inflammatory changes are seen in the pancreas?

Parenchymatous pancreatitis with a swelling and degeneration of the cells of the parenchyma. *Chronic interstitial pancreatitis* or *cirrhosis*, *tubercular* and *syphilitic pancreatitis*. These inflammations cause the usual changes, each of its own particular type.

What are the degenerative changes?

Atrophy, fatty degeneration, fatty infiltration and *amyloid degeneration.*

What tumors occur in the pancreas?

Carcinomata cysts, due to a dilatation of the panereatic ducts. Concretions of carbonate and phosphate of lime are frequently found in the panereatie duets also.

SALIVARY GLANDS.

What forms of inflammation have been noted in the salivary glands?

Acute and *chronic.* The chronic inflammations lead to a formation of new connective tissue; that is, it is of the productive type of inflammation. The aeute inflammations are of the exudative type. The affected gland is infiltrated with leueocytes, and the gland cells may be swollen and broken down. Abscesses may be developed. The aeute glandular inflammation ealled "*mumps*" usually affects the parotid, although the submaxillary gland may be affected.

What changes may occur in the ducts of salivary glands?

They may become inflamed from the presenee of foreign bodies, or of concretions of lime salts. They may become occluded and widely dilated and filled with salivary fluid. In this manner ranulæ are formed.

THE DUCTLESS GLANDS.

What tumors have been observed in these glands?

Fibromata, *chondromata*, *sarcomata* and *myxomata.* Most often the tumors developed in these glands are of the mixed types, composed of several of the above in varying proportions.

THYROID GLAND.

What changes may occur in the thyroid?

It may be hyperæmic or be the seat of hemorrhages. Simple inflammations, either acute or ehronie, are rare, as also are the syphilitie and tubercular forms of inflammation. The gland eells may undergo eolloid degeneration and thus the gland alveoli become filled with colloid material. Amyloid degeneration of the gland or of its vessels is rare.

What changes take place in the thyroid in goitre?

There may be an enlargement of the gland by a simple hyperæmia, but in true goitre the increase in size is caused by the formation of new, and the enlargement of old, gland alveoli. There is also more or less colloid degeneration. Accumulation of fluid, colloid, blood, etc., in the gland alveoli may cause the formation of cysts. There may be hemorrhages, pigmentation, calcification, purulent or indurative inflammation. Carcinomata or sarcomata may be associated with the goitre.

What is the appearance of the thyroid in myxœdema?

The gland is atrophied. The parenchyma is replaced to a greater or less extent with fibrillar connective tissue and newly-formed reticular tissue.

What tumors have been found in the thyroid?

Sarcomata, usually primary growths, *melano-sarcomata* and *carcinomata.*

THYMUS GLAND.

What pathological changes have been observed in the thymus?

Small hemorrhages, suppurative inflammations, syphilitic and tubercular inflammation and sarcomata.

SUPRA-RENAL CAPSULES.

What form of inflammation is most frequent in the supra-renal capsules?

Tubercular inflammation. The organs are increased in size, and their normal structure is replaced by tubercle tissue, connective tissue and cheesy matter. These are the changes found in "Addison's disease." Suppurative inflammation has been seen in a few cases.

What forms of degeneration have been found?

Fatty degeneration of the cortical part is the rule in adults, but in children under five years of age it is a pathological condition.

Amyloid degeneration may involve a part or the whole of the organ.

What tumors have been found in the supra-renal capsules?

Carcinomata, *sarcomata*, *neuromata* and *gliomata* have been observed.

THE CIRCULATORY SYSTEM.

PERICARDIUM.

Aside from inflammatory changes, what pathological conditions may be observed in the pericardium?

It may be perforated or it may be ruptured. The pericardial sac may contain a quantity of serous fluid usually clear and of a light-yellow color. The sac may contain blood from hemorrhage, or there may be small extravasations of blood into the walls of the sac. The condition pneumatosis may occur from perforating wounds with the entrance of air into the cavity of the pericardium.

What forms of inflammation occur in the pericardium?

Exudative and *Tubercular.*

Name and describe the different forms of exudative pericarditis.

1. *Pericarditis with the production of fibrin.* In mild cases of this class the pericardium is congested and its surface covered with a thin layer of fibrin. In more severe cases the layer of fibrin is thicker, with fibrinous adhesions between the parietal and visceral walls of the pericardium. The walls may be infiltrated with leucocytes. The fibrinous adhesions may be absorbed or may be replaced by new connective tissue.

2. *Pericarditis with the production of fibrin and serum.* In these cases the changes are the same as above with the addition that there is a large effusion of serum into the pericardial sac.

3. *Pericarditis with the production of fibrin, serum and pus.* This form may begin as one of the varieties just described or it may be purulent from the start. These cases are apt to run a chronic course.

What is to be said of tubercular pericarditis?

It may occur as a primary inflammation, but is usually associated with tubercular inflammation of other parts. It may occur in the form of miliary tubercles scattered diffusely or limited to certain portions of the pericardium. Sometimes the pericardium is thickened.

What tumors have been observed in the pericardium?

Fibromata, sarcomata and *carcinomata* (usually of secondary origin) and *endotheliomata.*

HEART.

Aside from degenerative and inflammatory changes, what pathological changes are found in the heart?

The heartwall may be penetrated or ruptured. The heart may be

atrophied, or hypertrophied, or be dilated. These conditions are best considered in works on general medicine.

Name the forms of degeneration occurring in the heart, and describe them.

(1) *Parenchymatous degeneration of the heart musele* in which the muscle fibres are filled to a greater or less degree with albuminous granules. This may be followed by a (2) *fatty degeneration of the heart musele*, portions of the muscle fibre being transformed into larger or smaller drops of fat. (3) *Fatty infiltration of the heart* shows an unusual accumulation of fat about the heart and *between* its muscle fibres. Fatty degeneration may be present in the heart valves or in spots over the pericardium. (4) *Amyloid degeneration of the endocardium and walls of the bloodvessels* is sometimes seen. Lastly (5) *calcareous degeneration* may take place in the products of a simple inflammation that may have taken place in the heart.

Name the different forms of endocarditis.

Simple acute endocarditis.
Mycotic or malignant endocarditis.
Chronic endocarditis.
Chronic ulcerative endocarditis.
Tubercular endocarditis.

Describe simple acute endocarditis.

This form is most apt to occur as a complication of rheumatism. It may consist of a simple swelling of the heart valves, or there may be a splitting up of the basement substance of the endocardium and a marked increase or growth of connective-tissue cells with the formation of fungous masses or vegetations on the surface of the valves. These vegetations may break down and ulcerate. This is a *simple acute ulcerative endocarditis.*

Describe mycotic or malignant endocarditis.

The lesion may be a primary or secondary affection. It is an *acute endocarditis* incited by the presence of bacteria, most often streptococcus pyogenes, aureus, and albus. The newly-formed tissue soon becomes necrotic.

What changes occur in chronic endocarditis?

The endocardium may be thick and dense, and its free surfaces smooth or covered with small vegetations or ridges. It may be infiltrated with lime salts. There may be a growth of new connective-

tissue cells in the endocardium. Some of these cells may live, others degenerate, so that the endocardium may be destroyed in places. Fibrin is in it, and later it may become infiltrated with lime salts.

What are the changes in chronic ulcerative endocarditis?

Large ulcers or perforations may be formed by chronic endocarditis. Upon these ulcerations blood clots may form, so that the gross appearance of the diseased part resembles the changes produced by mycotic endocarditis.

Describe tubercular endocarditis.

It may occur with tubercular pericarditis or with general miliary tuberculosis. The changes produced are similar to those produced by tubercular inflammation elsewhere.

What is myocarditis, and what are the different varieties of this inflammation?

It is an inflammatory change affecting the heartwalls. The interstitial tissue and bloodvessels being involved primarily; secondary to this there are degenerative changes in the muscle fibres. The varieties of myocarditis described are:

(1) *Interstitial myocarditis*, which may be acute and purulent or chronic with the production of new connective tissue, and (2) *Syphilitic myocarditis.*

Describe the different forms of myocarditis.

In the acute purulent form there may be a diffuse infiltration of the heartwall with pus. Or the pus may occur in circumscribed patches forming abscesses which contain pus, broken-down muscle and necrotic tissue. The abscess may open into the pericardial sac or into the heart cavity, or may produce an aneurism in the heartwall. With the chronic form of myocarditis there is a growth of new connective and granulation tissue in the heartwall accompanied by an atrophy of the muscle fibres. Syphilitic myocarditis gives rise to the same changes as chronic myocarditis. In this form the pericardium and endocardium may be thickened, but gummata of the heart are rare.

What other changes of pathological interest have been observed in the heart?

The heart valves may become fenestrated, or may be the seat of aneurism, or there may be a hemorrhage into the valve tissue. The heartwall may contain sacs (filled with blood) which communicate with the heart cavities. These are aneurisms, and may be formed by

a weakening of the heartwall by endocarditis, myocarditis, or fatty degeneration. The heart cavities are often found after death to contain yellow, succulent, semi-translucent masses or colorless clots. They are formed during the last hours of life and are of no pathological significance. Masses of fibrin may form upon the heart valves or in any of the heart cavities during life. They are usually associated with some valvular lesion and are of a firm whitish appearance.

What tumors have been found in the heart?

Primary tumors are rare, but *sarcomata*, *fibromata*, *lipomata* and *myxomata* have been found.

BLOODVESSELS.

What forms of degeneration have been noted in bloodvessels?

Fatty degeneration, affecting the intima or media, or both; this may lead to the formation of an aneurism.

Calcareous degeneration, affecting the intima or media, usually occurs in vessels otherwise diseased.

Amyloid and also *hyaline degeneration;* these forms may implicate the entire vesselwall.

ARTERIES.

What is an aneurism?

It is the dilatation of the coats of an artery over a larger or smaller part of its course. Aneurisms are named according to their shape. When implicating the entire vesselwall for a longer or shorter space there is formed a *cylindrical aneurism.*

If the wall of one side of a vessel is affected, then there is formed a *sacculated aneurism.* These ordinary aneurisms are due to degenerative changes in and consequent weakening of the vesselwall. In cirsoid aneurism there is a dilatation and also a lengthening of the vessel, giving it a tortuous course. This form occurs as a rule in the smaller arteries.

To what inflammations are the arteries subject?

(1) *Acute arteritis*, with an exudation of leucocytes into the vesselwalls. This occurs usually as the result of injury. The inner coat may be affected (*endarteritis*), or the outer coat (*periarteritis*).

(2) *Chronic arteritis* in most cases is more marked in the intima, but may implicate all the arterial coats. The change consists of a production of new connective tissue and a thickening of the vessel-

wall. In some cases the production of new tissue is so great as to obstruct the lumen of the vessel (*obliterating endarteritis*). The new tissue produced in chronic arteritis is apt to be the seat of fatty or calcareous degeneration. The term *atheroma* has been applied to these changes, and by them erosions or ulcerlike patches are produced in the vesselwalls.

(3) *Syphilitic arteritis.* In this form there is a new growth of tissue resembling ordinary connective tissue.

(4) *Tubercular arteritis* produces the same changes as tubercular inflammation elsewhere.

VEINS.

What is phlebectasia?

It is a dilatation of a vein and may be seen as a *simple dilatation*, uniformly cylindrical or fusiform in shape, as a *cirsoid dilatation*, the vessel being not only uniformly dilated cylindrically but also increased in length, and lastly as a *varicose dilatation*, *i. e.*, dilatation of a circumscribed portion of the vesselwall into a globular sac.

What is phlebitis?

It is an inflammation of the wall of a vein; when implicating the outer wall it is called a *periphlebitis* and when affecting the inner wall an *endophlebitis*. The acute forms of phlebitis are of the exudative type of inflammation, the exudation coming from the walls of the vasa vasorum.

Describe the different varieties of phlebitis.

If the inflammation starts as a *periphlebitis* the vesselwalls are swollen, congested and infiltrated with serum and pus. If it starts as an *endophlebitis* the entire vesselwall is eventually similarly involved. In all cases there is the formation of a thrombus which may be absorbed, or remain and obliterate the vein, or degenerate and be carried into the general circulation as embolic masses. Chronic periphlebitis produces a thickening of the outer coats of the vein. Chronic endophlebitis is rare, but when it occurs produces about the same effect as chronic endarteritis. Syphilitic inflammation may produce gummata in the vesselwalls or a diffuse thickening. Tubercular inflammation may be produced by tubercle bacilli in the blood or by invasion from foci of tubercular inflammation adjacent to the veins.

LYMPHATIC VESSELS.

To what is lymphangitis due and what changes does it produce?

Lymphangitis or inflammation of the walls of the lymphatic vessels

is believed to be incited by the entrance of some septic material from an injury or wound of adjacent structures. In mild cases there may be no microscopical changes that are apparent, but in the severe cases the wall of the affected vessel is infiltrated with pus, and its lumen may contain pus, fibrin, and desquamated endothelium. The presence of tubercle bacilli may produce a tubercular lymphangitis. The vessel may also be the seat of gummata due to the poison of syphilis.

What forms of inflammation are common to lymph nodes?

Acute, chronic, tubercular and *syphilitic inflammations.*

What are the changes in acute inflammation?

This form of inflammation is usually secondary to inflammatory change in the vicinity of the affected node. There is a marked increase of cells in all parts of the node. In the follicles and cords these cells are small and round resembling those normally present. In the lymph sinuses are large polyhedral cells with large nuclei. The endothelial cells lying on the reticular structure of the node are swollen. The bloodvessels may be swollen and blood may be free in the lymph sinuses or in the follicles. This form of inflammation may terminate in resolution, the new cells undergoing fatty degeneration and being absorbed. Or the inflammation may become purulent and so extensive that abscesses are formed. Lastly, acute inflammation sometimes passes into the chronic form.

What changes are seen in chronic inflammation of lymph nodes?

There is simply an increased growth of connective tissue in the capsule, and trabeculæ and the reticular structure of the node becomes thickened and fibrous. As the amount of connective tissue increases there is a corresponding decrease in the number of lymphoid cells. The process may go on until the whole node is converted into a mass of connective tissue.

Describe tubercular inflammation of lymph nodes.

It may occur with simple inflammation, or be secondary to tubercular infection in other parts of the body.

The microscopical changes are the same as in tubercular inflammation elsewhere. These may be all. But often are noted in addition the following changes: The node is swollen and feels harder than normal. On section the cut surface is of a reddish gray color. The parenchyma cells, on microscopical examination, are found to be increased in number, some being small and spheroidal, others large and polyhedral. Some of the cells become filled with a highly refractile material, and

their nuclei do not take the staining fluids. Then larger or smaller masses of these cells undergo cheesy degeneration. They may remain in this condition for a long time or the cheesy material may break down and form abscesses which are very slow in healing.

What are the changes in syphilitic inflammation of the lymph nodes?

In the primary stage the lymph nodes in the infected region are apt to present the changes of ordinary acute inflammation. In the secondary stage the nodes in other parts of the body may be enlarged and hard. The connective tissue is increased in amount and there is an increase in the number of parenchyma cells. Such enlarged nodes may remain in the same condition for a long time.

In the tertiary stages the nodes may be the seat of a chronic inflammation with the formation of gumma tumors.

Describe pigmentation of lymph nodes.

Frequently pigment is found in lymph nodes, which has been derived from the coloring matter of the blood in the node or that has been brought from without. Often particles of dust, etc., that have entered the lungs with inspired air get into the lymphatics and from them into the lymph nodes. The presence of these materials often sets up a chronic inflammation.

What forms of degeneration are found in lymph nodes?

They may atrophy as a regular occurrence in old age, and are then small, hard and white unless pigmented. Amyloid and hyaline degenerative changes are rare and resemble the same changes occurring elsewhere.

What is a lymphoma?

It is a hyperplasia of a lymph node. In some cases there is an enormous increase in the size of nodes of certain regions. The increase may occur slowly or with great rapidity. The nodes may be hard or soft. The increase in size of the softer variety seems to be due to an increase in the parenchyma, while in the harder forms the increase in size is more confined to the reticular structure of the node. It may be regarded as a tumor.

What tumors have been found in lymph nodes?

Sarcomata, *fibromata*, *myxomata* and *chondromata*; *secondary carcinomata* are of frequent occurrence.

SPLEEN.

What disturbances of circulation are to be seen in the spleen?

Anæmia. In which condition the cut surface of the spleen is apt to look dry and pale.

Hyperæmia. Due usually to an obstruction of the portal circulation. The cut surface is red and may be soft or firm. If the hyperæmia is of long standing there is an increase of interstitial connective tissue.

Acute congestion. The capsule is tense and the pulp soft and red.

Infarction of spleen. Due to embolism. The infarctions are usually wedge shaped. At first red in color later they may become pale. If the infarction is due to an infectious embolism there may be suppuration.

Name the inflammations of the spleen.

Acute hyperplastic splenitis.
Suppurative splenitis.
Chronic indurative splenitis.
Tubercular splenitis.
Syphilitic splenitis.

What are the changes in acute hyperplastic splenitis?

The organ is enlarged and the pulp soft. Minute examination shows the enlargement to be due to a hyperæmia. There may be a swelling and an increase in the number of cells in the spleen pulp, and in the Malpighian nodes. The new cells may be large and multi-nucleated, or resemble the ovoidal and polyhedral cells of the pulp. Cells resembling leucocytes may be present in large numbers. The cells lining the cavernous veins may be increased in number or may be swollen.

Describe suppurative splenitis.

The changes are due probably to the presence of infectious emboli, and the changes are similar to those changes found in this type of inflammation in other parts. The spleen pulp may be so degenerated that it is changed to a soft, purulent mass enclosed in the spleen capsule.

What are the changes in chronic indurative splenitis?

There is a formation of new connective tissue. The spleen may be enlarged or be of normal size. The consistenee is usually firmer. There may be a hyperplasia of both pulp and trabecular tissue. The parenchyma cells may be increased in size and number, and the cells lining the cavernous veins increased in number. The reticular structure may be swollen.

What is said of the changes of tubercular and syphilitic splenitis?

The lesions are similar to those common to these types of inflammation.

Describe other inflammations of the spleen.

There may be a *peri splenitis* either *acute*, with the formation of fibrin and pus upon the surface of the organ, with more or less peritonitis, or the process may be *chronic*, with an increased production of connective tissue in the capsule producing a thickening.

What changes take place in the spleen in leukæmia and pseudo-leukæmia?

The changes are the same in both conditions. Usually the spleen is enlarged, and on section may be red, or mottled red, and gray. The minute changes are about the same as in acute hyperplastic and chronic interstitial splenitis.

What are the degenerative changes in the spleen?

Atrophy. The parenchyma cells being decreased in number.
Amyloid degeneration, especially of the Malpighian nodes.
Pigmentation.

What tumors have been found in the spleen?

Primary tumors are rare. *Small fibromata*, *angiomata* and *sarcomata* have been found, but sarcomata and carcinomata usually occur as secondary growths.

THE URINARY ORGANS.

KIDNEY.

What are the different forms of inflammation of the kidney?

Acute and *chronic nephritis.*
Suppurative nephritis.
Tubercular nephritis.

Give the classification of the different varieties of acute and chronic nephritis.

Acute congestive nephritis.
Acute degenerative nephritis.
Acute exudative nephritis.
Acute diffuse nephritis.
Chronic congestive nephritis.
Chronic degenerative nephritis.

Chronic diffuse nephritis with exudation.
Chronic diffuse nephritis without exudation.

What changes occur in acute congestive nephritis?

There is an increased amount of blood in the organ producing a hyperæmia. The condition is transient and there are no microscopical changes.

Give the changes occurring in acute degenerative nephritis.

This condition, sometimes known as parenchymatous inflammation, or as cloudy swelling, occurs principally in the cells lining the convoluted portions of the uriniferous tubules, and in the cells lining the capsule of Bowman. The changes that occur in the renal epithelium are, viz.: a swelling of the cell-body and an infiltration with albuminoid granules and fat. The cells break down, degenerate and crumble or desquamate. A growth of new cells takes the place of the cells destroyed. Casts are sometimes formed in the straight tubules, and there may be a congestion of the bloodvessels, with an exudation of serum.

What changes occur in acute exudative nephritis?

They are the same as are seen in any exudative inflammation, viz.: *Congestion*, *emigration of white-blood cells*, *exudation of blood plasma* and *red-blood cells*. There are changes also in the *tubules*, *stroma* and *Malpighian capsules of the kidney*. In the tubules the lining cells may be flattened or swollen and detached. The tubules themselves may be dilated and may contain cylinders or irregular masses of hyaline material, identical in composition with the casts found in urine. There may also be red and white-blood cells free in the tubules. The *exuded* white-blood cells are collected in larger or smaller foci in the cortical portions of the kidney. In the Malpighian capsules the changes are very marked; the cells lining the capsule may be swollen; the cavity of the capsule may contain coagulated material, also both red and white-blood cells. On the capillary tufts there is a marked increase in the number of cells, which, in severe cases, even fill up the space between the tuft and inner wall of the capsule. In many cases the arterial walls are swollen.

What are the changes in acute diffuse nephritis?

They are the same as have been described in acute exudative nephritis, but with two additions, viz.: There is a growth of *connective tissue in the stroma* and a *proliferation of cells within the capsule of Bowman*. The growth of connective tissue occurs in strips or wedges, each wedge having one or more arteries with thickened walls. The

glomeruli supplied by an affected artery are usually compressed by the growth of capsular cells. After a time there may be a growth of connective tissue in the stroma between these wedges. The exudation from the bloodvessels is marked and the urine contains a quantity of albumen, many casts, red and white-blood cells.

Describe the changes produced in chronic congestive nephritis.

The kidneys are uniformly congested. The tubular epithelium is opaque, flattened or swollen, especially in the cortical portion of the kidney. The glomerular capillaries are dilated, and their walls thickened by the swelling of the cells which cover them. The kidney may be of medium size or increased in size, and its weight is increased.

What changes are found in chronic degenerative nephritis?

This condition is produced by long-continued disturbances of circulation, heart disease, etc. As a rule, the kidney is increased in size. The epithelium lining the tubules in the cortical portion of the kidney is swollen, coarsely granular and infiltrated with fat. If the lesion is due to a disturbance of circulation, the glomerular capillaries are dilated. There may be a slight exudation from the bloodvessels, but there are no changes in the stroma or arteries.

What changes are seen in chronic diffuse nephritis with exudation?

Usually the kidney is increased in size, but some are found that are smaller than normal. The surface may be smooth, nodular or granular. The cortex may be white or gray, mottled at times with yellow, gray, or red patches. From the bloodvessels there is a marked exudation, the products of which are found in the tubules, unless it has been carried off in the urine.

The tubules may be dilated and their lining epithelium flattened, or the epithelium may be degenerated and the tubule atrophied. Sometimes the tubules are filled with cast matter, or contain extravasated blood. There is a marked increase of the connective tissue of the stroma of the kidney.

The glomerular capillaries may be the seat of waxy degeneration. The arterial walls are thickened.

What changes are seen in chronic diffuse nephritis without exudation?

The changes are the same as in the preceding variety with the exception that the exudative products are absent. The kidney is usually atrophied but may be much increased in size. The increase in connective tissue is marked. Clinically these cases run a much slower course than the preceding class.

What are the causes of, and what changes occur in, suppurative nephritis?

The inflammation may be started by injury, bacterial emboli, or may arise from undiscoverable causes. The inflammatory process is an exudative one. The whole kidney may be converted into a mass of pus, blood and broken-down tissue, or there may be a formation of circumscribed abscesses. When caused by infectious emboli the kidney may be dotted with little white points surrounded by a red zone. Micrococci may often be found. In some cases the whole kidney may be so changed that it is nothing but a sac filled with pus.

What are the changes in pyelo-nephritis?

The mucous membrane of the pelvis is congested, thickened, and there may be patches of fibrin upon its surface. The renal epithelium is swollen and degenerated. Abscesses and collections of pus may be scattered through the kidney and there may be an exudation of pus-cells between the uriniferous tubules.

What are the lesions in chronic pyelo-nephritis?

The mucous membrane lining the pelvis and calices of the kidney, and the epithelium covering the diseased surfaces may be changed and little polypoid growths be formed. There may be a layer of granulation tissue formed beneath the epithelial layer. The mucous membrane may be covered with pus and fibrin, or the pelvis of the kidney may be filled with pus. There is a marked increase in the amount of connective tissue in the kidney. Pus may also be present in the kidney itself.

Describe tubercular inflammation of the kidney.

The inflammatory process is the same as in tubercular inflammation elsewhere. It may occur in a kidney already the seat of a chronic diffuse nephritis, or the nephritis may be added to the tubercular inflammation.

What are the causes of, and changes found with, hydronephrosis?

This condition is produced by an obstruction to the flow of urine from the pelvis of the kidney, and may be congenital or mechanical. The kidney tissue is flattened out by the pressure of the retained urine. It may remain normal or may be the seat of a suppurative nephritis or of a chronic diffuse nephritis.

What can be said of cysts of the kidney?

These cysts may be congenital, and seem to be formed by dilatation

of the tubules and Bowman's capsules, due probably to occlusion of the tubules.

In adult life there may be one or more cysts which do not seem to interfere with the function of the kidney. In chronic diffuse nephritis there may be an occlusion of the tubules and a production of cystlike cavities.

What is a peri-nephritis?

The loose tissue surrounding the kidney may become the seat of an exudative inflammation. Primarily it may occur from exposure to cold or from great muscular exertion; secondarily, from the extension of exudative inflammation in its vicinity. The kidney may be compressed by the abscess, or may become the seat of a suppurative inflammation.

What tumors have been seen in the kidney and pelvis of the kidney?

Fibromata, *lipomata*, *papillomata*, *adenomata*, *angiomata*, *myxosarcomata*, *myomata*, *lymphomata*, *sarcomata* and *carcinomata*.

BLADDER.

Give changes in size and position of the bladder with causes.

The bladder may be the seat of a general dilatation from an accumulation of urine due to obstruction, or the dilatation may occur in circumscribed spots producing diverticula. The walls of these diverticula may include all the layers of the bladderwall, or may consist of the mucous membrane alone which has protruded between the bundles of muscle fibres. The bladderwall may be thickened by mechanical obstruction to the outflow of urine. Hernia of the bladder may accompany intestinal hernia, or, as in the female, may press upon the vaginal wall, causing a protrusion (*vaginal cystocele*).

What disturbances of circulation may occur in the bladder?

There may be a chronic hyperæmia due to an obstructed venous circulation, or there may be hemorrhages caused by pressure or by the presence of calculi or tumors, or there may be small hemorrhages into the mucous membrane of the bladder.

Classify the different forms of inflammation as occurring in the bladder.

Acute cystitis.

Chronic cystitis.

Croupous inflammation of the bladder.
Tubercular cystitis.

What are the changes in an acute cystitis ?

The mucous membrane is congested and swollen, and there is a desquamation of the lining epithelium, sometimes with a formation of superficial or deep ulcers. The changes may be so slight as not to be evident after death.

What changes occur in chronic cystitis ?

The mucous membrane is swollen and gray in color, or it may be mottled with spots of congestion. The membrane may be infiltrated with pus, and thickened either diffusely or in the form of tufts or polypi; sometimes it becomes atrophied. The epithelial cells covering the inner wall become cast off, especially on the more prominent points, and deep ulcers may be formed. Sometimes the muscular coats become paralyzed. The inflammatory process at times assumes a more necrotic character. There may be a necrosis implicating all the coats of the bladder, producing perforation. In some cases all the different layers of the bladderwall may become infiltrated with pus. producing abscesses which may open internally or externally.

Describe croupous inflammation of the bladder.

The inner surface of the bladderwall may become coated with a layer of fibrin, in which are entangled pus and epithelial cells. The fibrin may infiltrate the mucous membrane separating the cells of which it is composed. This form of inflammation may occur with either of the preceding forms.

How does tubercular inflammation affect the bladder ?

It begins as miliary tubercles in the bladderwall. These tubercles breaking down form ulcers.

What tumors have been found in the bladder ?

Fibromata and *carcinomata.*

What are vesical calculi ?

They are concretions found in the bladder, and range in size from a mustard seed to masses four or five inches in diameter. They are of different shapes and may be smooth or rough. Their most common constituents are phosphates, urates, uric acid and oxalate of calcium.

To what may changes in the size of the urethra be due ?

There may be dilatation caused by obstruction from stricture or by impaction of a calculus or foreign body. The calibre of the urethra

may be decreased in size by strictures which have followed some preceding inflammation or ulceration. Or the decrease in size of the urethra may be due to constriction caused by a fibrous induration of the corpus spongiosum.

What are the changes in, and causes of, catarrhal urethritis?

The mucous membrane is congested and swollen and covered with muco-pus. This form of inflammation is due to the action of chemical irritants, to extension of an inflammatory process from other parts, to unknown causes and to the action of gonorrhœal poison. The most common cause is the latter. In the exudation of gonorrhœal inflammation there is always present a form of coccus called the gonococcus. The constant presence of this particular form of coccus seems to render it fairly certain that it is the cause of this form of inflammation. This fact has not been definitely settled, however. (Peculiarities of this coccus will be noted in the section on *bacteriology*.)

What other forms of inflammation have been observed in the urethra?

Croupous inflammation with the formation of fibrinous casts of the urethra have been seen in children.

Syphilitic ulcers may occur at the meatus and as far back as the fossa navicularis. Tubercular inflammation rarely occurs.

What tumors may occur in the urethra?

There may be polypoid growths from the mucous membrane, or there may be circumscribed masses of dilated veins. Carcinomata may extend to the urethra from adjacent organs.

THE FEMALE ORGANS OF GENERATION.

VULVA AND VAGINA.

What disorders of circulation may occur in the vulva?

There may be hemorrhage from ulceration or injury, or there may be an extravasation of blood into the connective tissue of the vulva. This blood may be absorbed or may decompose with suppuration or gangrene of the surrounding tissue. Varicose veins may occur in the vulva, or the part may become œdematous especially in pregnant women.

What inflammatory conditions are common to the vulva?

Acute and *chronic catarrhal inflammation*, *syphilitic inflammation*, *erysipelatous inflammation*, *suppurative inflammation* and *croupous*

inflammation, with changes characteristic each of its own variety, have been observed.

What tumors have been found in the vulva?

Fibromata, papillomata, lipomata, fibro-sarcomata and *carcinomata.*

What inflammations are common to the vagina?

Catarrhal inflammation.
Croupous inflammation.
Suppurative inflammation.
Tubercular inflammation.
Syphilitic inflammation.

Describe catarrhal inflammation of the vagina.

It may be acute or chronic and is most frequently caused by the action of gonorrhœal poison. In the acute form the mucous membrane is swollen, congested and covered with muco-pus. In the chronic form, besides the above changes, there may be an exfoliation of epithelium and the formation of ulcers. In some cases the mucous membrane is thickened and may be roughened by papillary growths.

Describe croupous inflammation.

The mucous membrane is swollen and covered with fibrin and pus. It, together with the submucous coat, may be *infiltrated* with fibrin. The process may be so severe that both the mucosa and submucosa may become gangrenous.

Describe suppurative inflammation.

It is an exudative inflammation of the fibro-muscular coat of the vagina, and may lead to the formation of abscesses and sloughing of the vaginal wall.

What is to be said of tubercular and syphilitic inflammation of the vagina?

The changes due to each are the same as occur elsewhere with these different forms of inflammation.

What tumors have been found in the vagina?

Fibromata, myomata, sarcomata and *cysts.*

UTERUS.

Changes in *size* and *position* of the uterus are considered in the works on Gynæcology and Obstetrics of this series.

What are the inflammations of the unimpregnated uterus?

Acute catarrhal endometritis.

Chronic endometritis.
Croupous endometritis.
Tubercular endometritis.
Syphilitic endometritis.
Acute metritis.
Chronic metritis.
Peri-metritis.
Para-metritis.

Describe acute catarrhal endometritis.

The mucous membrane is swollen, hyperæmic and may be the seat of small hemorrhages. The corium may be infiltrated with small round cells and the epithelium desquamated. The surface of the mucous membrane may be covered with muco-pus. In the more severe cases the entire mucous membrane may be exfoliated and the body of the uterus be swollen and hyperæmic.

Causes: Exposure during menstruation, acute infectious diseases, gonorrhœal infection.

Describe chronic endometritis.

The changes in the mild cases may be very slight and resemble those of the acute variety. In the more severe cases there is a marked increase of connective tissue in the mucous membrane, which may present a roughened surface or have polypoid growths upon it. Sometimes the mucous membrane is covered with a layer of vascular tissue covering in many of the uterine glands. Ulceration of the mucous membrane may occur, especially at the cervix, and lead to cicatricial contraction.

Describe the remaining forms of endometritis.

They all present the same changes microscopically as the same forms of inflammation elsewhere.

What is metritis?

It is an inflammation of the body of the uterus, and may be acute or chronic. In the acute form the uterus is swollen, congested and soft. There may be a formation of abscesses from a suppurative inflammation. In the chronic cases the organ may be congested and soft or it may be hard, on account of the formation of new connective tissue.

What is a peri-metritis?

It is an exudative inflammation attacking the peritoneal coat of the uterus. There may be a production of pus, and adhesions may be formed.

What is a para-metritis?

It is a suppurative inflammation attacking the connective tissue about the uterus and within the folds of the peritoneum.

What forms of inflammation are found in the pregnant uterus?

The forms just described may attack the pregnant uterus. Another form of inflammation, called *puerperal inflammation*, may occur. It is caused by injury during or after delivery, and the action of some infectious material that may have been absorbed at the same time. The changes are similar in character to those of any of the subvarieties of exudative inflammation and may attack other parts to which some of the infectious material may have been carried by the blood or lymphatics. In this way foci of suppurative inflammation with the formation of metastatic abscesses may be produced.

What forms of ulceration may attack the uterus?

Catarrhal, *tubercular* and *syphilitic* ulceration may occur with their respective varieties of inflammation; another form *phagedenic* or *corroding ulcer* usually occurring in old age, may attack the cervix uteri and adjacent parts. This form has indurated walls and a dark or black roughened base. It is probably a form of carcinoma.

What degenerations have been noted in the uterus?

Fatty degeneration and amyloid degeneration.

What forms of tumors have been found in the uterus?

Fibromata, *myomata*, *angiomata*, *sarcomata* and *carcinomata*.

OVARY.

What forms of inflammation are seen in the ovary?

Acute inflammation.

Chronic interstitial inflammation.

Tubercular and syphilitic inflammation.

The two latter forms show changes common to them in other parts.

What are the changes in an acute inflammation of the ovary?

The stroma is swollen, congested and soft. It is infiltrated with serum and pus which may result in the formation of abscesses. If the inflammation attacks the capsule, adhesions may be formed with adjacent parts.

What changes are seen in chronic interstitial oöphoritis?

There is an increased growth of new tissue which may be a loose and cellular, or a hard and dense connective tissue. It may be formed

in the stroma or in the capsule, producing either an increase or decrease in the size of the organ. The veins may be largely dilated.

What tumors have been seen to occur in the ovary?

Fibromata, *leiomyomata*, *sarcomata*, *carcinomata* and *adenomata*.

Name the different forms of cysts found in the ovary.

Cystic adenomata or *compound ovarian cysts*, *follicular cysts*, and *dermoid cysts*.

Describe a compound ovarian cyst.

This form is made up of a number of compartments (*multilocular*). It seems to begin as a glandular or adenomatous growth, and its divisions are filled with a semi-fluid material. As the cyst increases in size other cavities are formed. The stroma of the cystwall is made up of a fibrous material lined with cylindrical cells, which by the accumulation of fluid may become flattened or degenerated. The fluid contents of these cysts may be thick or thin, but is always viscid. In the fluid may be found red-blood cells, pus-cells, cylindrical, flattened, or polyhedral epithelial cells, well preserved or in a state of fatty degeneration, cholesterin crystals and fat droplets.

What is a follicular cyst?

It is a unilocular cyst formed probably by the dilatation and accumulation of fluid in a Graafian follicle. The fluid may be serous or viscid and turbid.

What are dermoid cysts?

They are cysts, the inner walls of which may be made up of the same elements as are found in the skin. They are usually filled with a thick, white, greasy material and may contain bits of bone or cartilage or hair. After a time they may become the seat of a calcareous degeneration.

What are parovarian cysts?

They are cysts formed in the tubules of the parovarium between the peritoneal layers of the broad ligament, and usually are lined with cylindrical ciliated cells and filled with a serous fluid.

FALLOPIAN TUBES.

What forms of inflammation are found in the fallopian tubes?

Catarrhal salpingitis.
Suppurative salpingitis.
Tubercular salpingitis.
Syphilitic salpingitis.

Describe the changes in the different forms of salpingitis.

The two latter forms present the characteristic changes common each to its own type of inflammation.

In the first form the mucous membrane is hyperæmic and swollen; it may be covered with a layer of muco-pus. The changes due to this form may disappear or may become chronic, resulting in adhesions, dilatation, or obliteration.

In the suppurative form there is an exudation of pus into the wall and mucous membrane of the tube. The lumen of the tube may be dilated and be filled with pus (*pyosalpinx*). Perforation may occur and the pus escape into the abdominal cavity, or the exudation may undergo a calcareous degeneration.

MAMMARY GLANDS.

What are the different forms of inflammation common to the female breast?

Acute mastitis.
Chronic mastitis.
Syphilitic mastitis.

Describe them.

Acute mastitis is an exudative inflammation, (without the production of pus,) and may involve the subcutaneous tissue, the glandular portion or the areolar tissue between the gland and wall of the thorax. At first the affected portion is hard, swollen, congested and painful. It may stop here and the inflammatory products be absorbed, or it may go on to suppuration with the formation of abscesses. This condition may cause great destruction of gland tissue. *Chronic mastitis* is a productive inflammation with the production of new connective tissue and consequent atrophy of the glandular elements. *Syphilitic mastitis* may occur in the form of ulcers upon the nipples.

What tumors have been found in the mammary glands?

Fibro-adenomata, *myxomata*, *chondromata*, *sarcomata* and *carcinomata*.

THE MALE ORGANS OF GENERATION.

PENIS.

Describe the various inflammations of the penis.

They are produced by injury, irritation or infection with specific germs. The prepuce may be swollen and red, or may ulcerate from

the irritation of retained smegma or gonorrhœal discharge. Retraction of a narrow prepuce behind the glans penis, with consequent stricture, may produce an inflammation sometimes followed by gangrene. Syphilitic ulcers may occur on any portion of the penis. Inflammation of the corpora cavernosa produced by any cause may result in a fibrous induration of the part.

What tumors occur on the penis?

Papillomata, fibromata, lipomata, angiomata and *carcinomata.*

What are the lesions of the scrotum?

Those common to skin elsewhere are found here also. A condition of elephantiasis may occur, which consists of a growth of new connective tissue and a dilatation of the lymphatic vessels in the skin. The new growths that have been observed here are as follows: *Fibromata, lipomata, sebaceous* and *dermoid cysts* and *epitheliomata.*

TESTICLE.

What forms of inflammation are found in the testicle?

Acute orchitis.
Chronic orchitis.
Tubercular orchitis.
Syphilitic orchitis.

Describe acute orchitis.

It is an exudative inflammation. The organ is swollen, congested and infiltrated with serum or pus. The inflammatory products may be absorbed or abscesses be formed which may undergo cheesy or calcareous degeneration. The abscesses may open externally and healing take place by the formation of granulation tissue.

What changes take place in a chronic orchitis?

It may follow the acute process or occur as an independent condition. There is a marked increase of interstitial connective tissue with an atrophy of the seminiferous tubules. Or the walls of the tubules may be thickened and they may be converted into fibrous cords. The tunica albuginea may be thickened or the whole testicle may be converted into a mass of fibrous tissue.

What changes are seen in tubercular and syphilitic orchitis?

Both these forms of inflammation show the peculiar changes common to the same types of inflammation as heretofore described.

What tumors have been found in the testicle?

Fibromata, lipomata, chondromata, sarcomata, adenomata, and *carcinomata.*

PROSTATE.

What are the lesions of the prostate?

It may be hypertrophied from senile changes. The hypertrophy is due to an increase of muscular or glandular elements. The prostate may be atrophied as a result of injury or inflammation. The inflammation may be caused by gonorrhœal infection or by injuries, and may be of the acute exudative or of the chronic productive variety. The prostate also may be the seat of a tubercular inflammation.

What tumors have been found in the prostate?

Adenomata and *carcinomata.*

THE BONES.

Name the different classes of inflammation affecting bones.

Periostitis, affecting the periosteum.
Osteitis, affecting the bony tissue.
Osteomyelitis, affecting the marrow and bony tissue.

Name the varieties of periostitis.

Simple acute periostitis.
Suppurative periostitis
Fibrous periostitis.
Ossifying periostitis.
Tubercular and syphilitic periostitis.

Describe simple acute and suppurative periostitis.

In the simple acute form the periosteum is thickened, congested and more or less infiltrated with leucocytes and serum, the connective-tissue fibres are swollen. The periosteum becomes more or less firmly adherent to the bone, and in the inner layer the cells are increased in number. This may terminate by resolution or may continue as a suppurative inflammation. This form may begin as a purulent process. There may be a collection of pus between the periosteum and bone, or in the periosteum itself. The affected parts may break down and become gangrenous, or the pus may be absorbed or become dry or

cheesy. If the separation of the periosteum from the bone is extensive the bone may undergo necrotic changes.

What are the changes in fibrous periostitis?

This is a chronic inflammation of the productive class and results in the formation of new connective tissue in the periosteum with a consequent thickening of this membrane.

What is an ossifying periostitis?

It is a process resulting in the formation of bony masses or spiculæ of bone between the periosteum and shaft of a bone. These masses, if circumscribed, are called *osteophytes.*

What are the changes in tubercular and syphilitic periostitis?

In the first variety miliary tubercles are formed in the periosteum. In syphilitic form the specific poison may give rise to any of the preceding varieties of periostitis except the tubercular, or there may be a formation of gumma tumors.

What are the forms of osteitis?

Rarifying osteitis.
Condensing osteitis.
Suppurative osteitis.
Tubercular osteitis.
Syphilitic osteitis.

What changes are seen in rarifying osteitis?

Under the periosteum, in the Haversian canals, and in the marrow spaces, there is formed a new, very cellular and vascular tissue, resembling granulation tissue. In connection with this there is an absorption of the bony substance. In this way irregular-branching canals with ragged walls may be formed in the bone, or there may be irregular masses of bone surrounded by the new tissue.

What is condensing osteitis?

It is a formation of new bony material on the surface, in the marrow cavities or in the Haversian canals.

Describe suppurative osteitis.

It usually begins as a rarifying osteitis and is really a part of an osteomyelitis. The marrow suppurates, the bony material is destroyed and a cavity is formed filled with pus and lined with granulation tissue.

What are the changes produced by tubercular and syphilitic osteitis?

The changes are the same as in a rarifying osteitis with the added changes that are common to these two forms of inflammation.

What is osteomyelitis?

It is usually a suppurative inflammation of the marrow of bone, and may be due to idiopathic or traumatic causes. As the different parts of bone are so intimately connected they are all more or less affected. The periosteum may be swollen and sueculent, and may be the seat of abscesses. The bony tissue itself may as a result be more or less necrosed.

What is necrosis of bone?

It is a death of portions of bone and a real gangrenous condition. When the circulation is cut off from a certain portion of bone it dies, but from its hardness it retains its outward structural appearances. An inflammatory change similar to that in rarifying osteitis is set up between the living and dead bone, and finally causes a complete separation. The dead bone or sequestrum may be absorbed or layers of new bony tissue may formed about it.

How does caries differ from necrosis?

Caries is an ulceration of the bone with a *molecular* destruction of the bony tissue. While necrosis is a death of a *mass* or *masses* of bony tissue.

What is rachitis and what are the microscopical changes in bony tissue in this disease?

It is a disease affecting the formation and development of bone. Microscopically the cells in the cartilage preceding bony formation are irregularly arranged. The zone of ossification, and the spaces in the newly-formed bone are irregular. As these spaces are irregular in size and shape the bone is not as strong as normal and may be spongy.

What is osteomalacia?

It is a condition in which there is a gradual absorption of the inorganic salts of the bony tissue. As the salts are removed the fibrous basement substance and cells of the bone are left. This may become degenerated and followed by a growth of granulation tissue.

What tumors have been seen in bone?

Fibromata, *myxomata*, *osteomata*, *chondromata*, *sarcomata angiomata* and *carcinomata*.

THE MUSCULAR SYSTEM.

MUSCLE.

Name the varieties of inflammation found in muscle.

Suppurative myositis.
Acute parenchymatous myositis.
Chronic interstitial myositis.
Myositis ossificans.

What are the changes in suppurative myositis?

The muscle is œdematous and hyperæmic. The interstitial tissue is infiltrated with leucocytes. The exudative products may be so abundant that abscesses are formed with the exudation. Degenerative changes take place in the muscle fibres, they may become granular or undergo fatty or waxy degeneration.

Describe acute parenchymatous myositis.

It is a lesion the course of which is unknown. The muscle becomes swollen, soft and mottled with yellowish patches and there may be small hemorrhages in it. The muscle fibres become degenerated.

Give the microscopical changes in chronic interstitial myositis.

It is a productive inflammation with a production of dense new connective tissue. The muscle fibres atrophy on account of pressure from the new tissue.

What is myositis ossificans?

There is a new growth of bony tissue between the muscle fibres usually in the form of spiculæ. The growth may start from the periosteum of bone or from interstitial connective tissue.

Name the degenerative changes common to muscle.

Simple atrophy.
Progressive muscular atrophy.
Atrophia musculorum lipomatosa.
Fatty degeneration.
Hyaline degeneration.

What are the changes in simple atrophy and progressive muscular atrophy?

In the *former* the muscle fibres grow narrower than normal as a result of pressure due to various causes, and there may be an increased amount of connective tissue between the muscle fibres. The *latter* form is a combination of simple atrophy and chronic interstitial myositis. The

muscle fibres may become smaller than normal or split up into longitudinal fibrillæ or transversely into discoid fragments.

Describe the lesion atrophia musculorum lipomatosa.

There may be a growth of new connective tissue between the muscle fibres, which tissue is in turn replaced by fat-cells. The muscle fibres retain their normal appearance or may appear to be increased in size.

What other degenerations are seen in muscle?

Fatty and hyaline degenerations, showing the changes that have been described as occurring with these forms of degeneration elsewhere.

What tumors occur in muscle?

Fibromata, *chondromata*, *lipomata*, *myxomata* and *sarcomata* may occur as primary growths springing from the interstitial connective tissue. *Carcinomata* and *sarcomata* occur by extension from adjacent parts

THE NERVOUS SYSTEM.

BRAIN.

What are some of the gross pathological changes in the dura mater?

There may be hemorrhage in the membrane itself, between it and the cranium, or between the dura and pia mater. Thrombi may form in any of the venous sinuses.

What is pachymeningitis?

It is an inflammation of the dura mater.

Name the different inflammations of the dura mater.

Pachymeningitis, interna acuta.
Pachymeningitis, externa acuta.
Chronic pachymeningitis.
Tubercular pachymeningitis.
Syphilitic pachymeningitis.

What are the causes of and changes in acute pachymeningitis externa?

It is usually caused by disease of or by injury to the cranial bones. The membrane is swollen, soft and congested. There may be a suppurative inflammation with the formation of pus.

What are the causes of and changes in acute pachymeningitis interna?

It may be secondary to inflammation of the external surface of the dura, or may occur as a complication of pyæmia, chronic diffuse

nephritis, and the contagious eruptive diseases. The inner surface is lined with a soft, yellow exudation made up of fibrin and pus.

What are the changes in simple chronic pachymeningitis?

There may be simply a formation of new connective tissue in the dura, rendering it thicker and in many cases causing it to adhere to the cranium. Often there is formed a layer of delicate connective tissue containing numerous thin-walled bloodvessels. This form is sometimes called *pachymeningitis hæmorrhagica interna*. Blood may escape from these thin-walled vessels. The new tissue between the bloodvessels is made up of a homogeneous or fibrillated basement substance containing numbers of spheroidal, spindle and branching cells. Sometimes there are found in these cases small calcareous concretions called *brain sand*.

What is to be said concerning tubercular and syphilitic pachymeningitis?

The changes seen are the same as have been described before under the head of *inflammation*.

What tumors have been found in the dura mater?

Osteomata, *chondromata*, *fibromata*, *lipomata*, *endotheliomata*, *sarcomata* and *psammomata*. These latter are small pedicled tumors of sarcomatous material often containing particles of calcareous material resembling brain sand.

Name some of the gross pathological conditions seen in the pia mater.

The pia sometimes becomes œdematous. But the presence of fluid may be due to post-mortem changes. Hemorrhage may occur in the substance of the membrane itself or between the pia and dura mater.

Name the different forms of inflammation seen in the pia mater.

Acute meningitis.
Chronic meningitis.
Tubercular meningitis.
Syphilitic meningitis.

Describe acute meningitis.

This lesion occurs in two distinct forms, *acute cellular* and *simple acute meningitis*. In the former there is produced simply an increased number of cells similar to the cells normally present. There are no exudative products whatever.

In the latter form the changes are exudative in character. There is an exudation of leucocytes in the pia mater and along the blood-

vessels, together with the formation of fibrin and serum. The exudative products occur in varying proportions.

What are the microscopical changes in chronic meningitis?

There is a thickening of the pia mater by a production of new connective tissue and an exudation of fibrin, pus and serum. The walls of the bloodvessels may be thickened.

What are the characteristics of tubercular meningitis?

The tubercular inflammation is usually secondary to tubercular inflammation in some other part of the body. The inflammation is present commonly in the form of miliary tubercules, and is especially liable to occur near or around a bloodvessel, which, at the same time, may be the seat of an obliterating endarteritis. Products due to an accompanying exudative inflammation are also present.

Describe syphilitic meningitis.

There is a formation of gumma tumors. With this process there is usually associated a simple exudative inflammation with the production of fibrin, serum and pus.

What tumors occur in the pia mater?

Sarcomata, *endotheliomata*, *fibromata*, *lipomata*, *angiomata* and *myxomata* may occur as primary growths. *Carcinoma* may occur as a secondary condition.

Describe acute ependymitis.

It is an exudative inflammation of the ependyma, occurring by itself or in connection with other inflammations of the brain. The bloodvessels are more prominent and the ependyma is infiltrated with pus. The surface of the membrane is covered with fibrin and pus, and the ventricles of the brain may be filled with purulent serum.

What are the changes in chronic ependymitis?

The ependyma is thickened by a growth of new connective tissue and the ventricles of the brain may contain more serum than usual.

What is hydrocephalus?

It is a condition in which the ventricles of the brain are dilated and contain more fluid than is normally present. This condition is often associated with the different forms of ependymitis.

Name the different varieties of chronic hydrocephalus.

Congenital hydrocephalus, which is present at or develops soon after birth.

Secondary hydrocephalus, seen in children and adults.
Primary hydrocephalus, seen in adults.

What are the causes of and changes seen in these different forms?

The first form develops at or soon after birth. The accumulation of fluid in the ventricles may crowd the brain tissue into a thin layer or cause its destruction. The bones of the skull may bulge out and the head become enormously enlarged. In the second class of cases the condition may be the result of some form of meningitis, of alcoholism, or of the general paralysis of the insane. As the cranial bones are better developed changes in the size and shape of the head are unusual. The cause of the last form is not well understood. It usually occurs in adults past thirty years of age.

What tumors occur in the ependyma?

Fibromata, *lipomata*, *angiomata*, *sarcomata* and *gliomata*.

What pathological changes have been noted in the pineal gland?

It may become hypertrophied and hard or be the seat of small cysts, or may participate in inflammatory changes involving adjacent parts.

What pathological changes may occur in the pituitary body, and what tumors have been seen in it?

Simple inflammation extending from adjacent parts. *Tubercular* and *syphilitic inflammation*.

Adenomata, *sarcomata* and *carcinomata* may occur.

What are the causes of thrombosis and embolism in the cerebral arteries?

Thrombi may be found as a result of pressure upon a vessel from without, or from degenerative or inflammatory changes in the wall of the vessel. Emboli may arise from an acute or chronic endocarditis or cardiac thrombi, or from atheroma of the aorta, carotid or vertebral arteries.

What effects are produced by thrombi or emboli?

If a large vessel is blocked up by an embolus the patient may die suddenly. If a smaller vessel is blocked up by a thrombus or embolus the region which is supplied by the vessel is deprived of blood. If there are anastomosing branches to the occluded vessel a collateral circulation is established, but if a terminal artery becomes stopped up the brain tissue to which it is distributed may become degenerated and softened.

What is the appearance of and changes in cerebral softening?

The degenerated area may be pale or red, the color depending upon the fact whether much or little blood is present. Microscopically the softened tissue is usually more or less fluid containing fragments of nerve fibre, degenerated brain tissue, droplets of myelin, nerve cells, shreds of neuroglia tissue and bloodvessels. Evidences of fatty degeneration are seen by the presence of fat-drops, cholesterin crystals and large and small cells infiltrated with fat.

What derangements of circulation may be present in the brain, and what appearances do they give rise to?

The brain may be hyperæmic, and on section may show an increased number of bloodvessels. The brain matter may be reddish in color. On the other hand there may be an anæmic condition in which a section of brain shows a decreased number of bloodvessels, and may look pale, with the markings between gray and white matter indistinct. The brain tissue may be œdematous.

What forms of hemorrhage may occur in the brain, and what changes are produced?

The hemorrhages may be small and punctate (*capillary hemorrhage*), or there may be the formation of clots of blood called *apoplectic foci.*

Microscopical examination of a brain which is the seat of a capillary hemorrhage may show a distension of the perivascular spaces due to an escape of blood, and the brain matter may be broken down. Adjacent brain tissue may be stained by the degeneration of the extravasated blood. The apoplectic foci or clots are made up of blood and broken-down brain matter.

What various forms of inflammation are seen in the brain?

A *simple exudative inflammation* or *encephalitis*, *chronic interstitial encephalitis* (*sclerosis*), *tubercular* and *syphilitic inflammation.*

Describe the changes produced in the brain by exudative inflammation.

Brain tissue in the neighborhood of hemorrhages and areas of thrombotic and embolic softening often becomes the seat of an exudative inflammation with exudation of leucocytes and red-blood cells. There is a local hyperæmia and the brain tissue is broken down. If the degenerated area is red from the presence of red-blood cells it is called *red inflammatory softening*, and if yellow or yellowish white with few red-blood cells it is called *yellow inflammatory softening.*

There may be multiple abscesses formed from pyæmie infection, or there may be large, single abscesses, some encapsulated and others not. The contents of these abscesses may be composed of thin or cheesy pus.

Describe chronic interstitial encephalitis.

There is a production of new connective tissue, neuroglia cells, and an atrophy of nerve elements. The lesion may occur diffusely or in circumscribed masses.

How does tubercular inflammation appear in the brain?

Usually in the form of solitary tubercles with cheesy centres.

How does syphilitic inflammation manifest itself in the brain?

By the formation of gumma tumors usually near the periphery of the brain. Sometimes it is characterized by the formation of a gelatinous, grayish tissue made up of a homogeneous or granular basement substance containing numerous small, round cells. The arteries may be the seat of an obliterating endarteritis.

What tumors have been found in the brain?

Gliomata, *glio-sarcomata*, *myxomata*, *fibromata*, *lipomata*, *osteomata* and *endotheliomata*. *Sarcomata* and *carcinomata* may occur as secondary growths.

SPINAL CORD.

What pathological changes are seen in the membranes investing the spinal cord?

The inflammatory changes are similar in variety and results to the inflammations occurring in the corresponding membranes investing the brain, with one exception. The dura mater spinalis is not adherent to adjacent bones and does not form their periosteum as does the corresponding membrane in the cranium. Therefore, it is not as readily involved in inflammatory disturbances affecting the bones. The varieties of tumors found are the same as in the dura and pia mater of the brain.

Do hemorrhages occur in the spinal cord?

Yes, either as capillary hemorrhages or as apoplectic clots. The changes produced resemble those due to the same lesion in the brain.

Give the classification of the inflammation of the spinal cord.

Acute myelitis.
Chronic myelitis.
Tubercular inflammation.

Syphilitic inflammation.

The two latter may give rise to the formation, the former to tubercles and the latter to gummata.

How are the acute inflammations of the cord classified?

Acute myclitis or *transverse myelitis.*
Acute disseminated myelitis.
Polio-myelitis anterior.

Describe transverse myelitis.

The gross changes are quite marked. The affected part is softer than the rest of the cord. The diseased portion may be red, white, yellow or gray. Microscopical examination may show blood or blood pigment, fragments of nerve fibre, more or less degenerated, also myelin droplets, fat droplets, large and small cells filled with fat droplets, granular matter and neuroglia cells. Sometimes small bodies resembling starch granules (*corpora amylacea*) are seen.

What changes are seen in acute disseminated myelitis?

The whole length of the cord is affected. It is swollen and congested. It is infiltrated with pus-cells, the connective-tissue framework is swollen, and the nerve fibres are degenerated.

What are the microscopical changes in polio-myelitis anterior?

The ganglion cells of the anterior gray cornua degenerate, atrophy and may become pigmented. There may be an increased amount of connective tissue in the cornua and in the anterior and lateral columns. There may be an atrophy of the anterior nerve roots and degeneration and destruction of a considerable portion of the anterior cornua.

What are the varieties of chronic myelitis?

Chronic transverse myclitis.
Multiple sclerosis.
Posterior spinal sclerosis or *locomotor ataxia.*

What are the changes in chronic transverse myelitis?

The lesion is due to pressure upon some portion of the cord. Instead of an inflammatory softening there is a local production of new connective tissue and a destruction of the nerve elements.

Describe multiple sclerosis.

There is a production of new connective tissue in patches in different parts of the cord involving gray or white matter or both. The nerve cells become atrophied and degenerated. The new connective

tissue consists of neuroglia cells with their branching processes or fibrillæ.

What are the changes in locomotor ataxia?

There is a production of new connective tissue in the posterior columns which may also implicate the posterior portion of the lateral columns. There is a degeneration and atrophy of the nerve fibres. Very often the walls of the bloodvessels are thickened.

To what is nerve degeneration often due?

Either to the destruction of the brain centre, from which the nerve fibre arises, or to a destruction or division of the nerve fibre between its point of origin and point of distribution.

What changes take place in the degenerated portion?

The medullary sheath and axis cylinder become granular and fatty and disintegrate. The degenerated part becomes grayish in color from absorption and from hardening due to the formation of new connective tissue. From the change in color this degeneration is called *gray degeneration*.

What are the different forms of gray degeneration?

Ascending and *descending gray degeneration.*

What parts of the cord are affected in ascending gray degeneration?

The sensory nerve fibres are affected. The parts involved are the columns of Goll in the posterior columns of the cord. It also affects the direct cerebellar tract and the columns of Gowers, both situated in the periphery of the lateral columns of the cord.

What parts of the cord are affected in descending gray degeneration?

The motor nerve fibres are alone affected. The degenerated area may or may not be extensive, depending upon whether the fibres run a long or short course before passing into ganglionic centres. The portions affected are the columns of Türck in the anterior columns, and the pyramidal tracts in the lateral columns of the cord.

What tumors are found in the spinal cord?

Tumors of the cord are rare. *Fibromata*, *gliomata*, *sarcomata*, *glio-sarcomata* and *neuromata* have been described as primary tumors. *Carcinoma* may occur as a secondary growth.

What is the lesion in syringomyelia?

There is a growth of gliomatous or glio-sarcomatous tissue in the vicinity of the central canal, which may expand with the formation of cavities of greater or less extent.

PERIPHERAL NERVES

What changes occur in peripheral nerves after division and separation from their trophic centres?

The medullary sheath breaks up into various-shaped droplets which become decomposed with the formation of fat. The axis cylinder is often destroyed. The nerve sheath with its nuclei does not usually degenerate. Sometimes after a variable period the nerve fibres become regenerated.

Name the different inflammations of the peripheral nerves.

Acute exudative neuritis.
Chronic interstitial neuritis.
Multiple neuritis.

What are the pathological changes in acute exudative neuritis?

The inflamed nerve is red and swollen and infiltrated with serum and pus. The process may undergo resolution or terminate in gangrene and destruction of the nerve.

What are the changes in chronic interstitial neuritis?

There is an increased growth of connective tissue in the nerve sheaths and intrafascicular bands with a consequent atrophy of the nerve fibres.

What are the causes of and changes in multiple neuritis?

On account of exposure to wet or cold, alcoholism, poisoning by lead or arsenic, a degeneration of the nerve fibres in different parts of the body may occur. This degeneration may be accompanied or followed by a proliferation of the neurilemma cells. In some forms of multiple neuritis there is an exudative inflammation, and new cells are found in or between the nerve fibres. Regeneration may take place after these changes.

What tumors have been found in peripheral nerves?

True neuromata, *false neuromata*, consisting of fibrous or myxomatous tissue; *myxo sarcomata* and *primary sarcomata*. *Carcinomata* and *sarcomata* may occur as secondary growths.

BACTERIOLOGY.

DEFINITION, OCCURRENCE, STRUCTURE, PRODUCTS AND DEVELOPMENT OF BACTERIA.

What are bacteria?

They are minute vegetable organisms of the simplest form. They are microscopic in size and contain no chlorophyl as do plants of higher types.

Where are they found?

In the air, water and surface soil. They are especially abundant about human habitations, or wherever there is decaying organic matter.

To what is putrefaction due?

To the presence and activity of bacteria.

What effect do bacteria have upon dead organic matter?

They separate the complex structures of animal and vegetable life into simpler compounds. A small part of the resulting elements they use as food while the greater part is set free. It is by the activity of these minute organisms that suitable food is prepared for more highly organized plants, which in turn go to support animal life. It can therefore be said that without the bacteria all life would ultimately cease.

What are saprophytes?

Saprophytes or saprophytic bacteria are the ones which grow upon dead organic matter and cause decomposition and fermentation.

What are parasites?

Parasites or parasitic bacteria require as their place of growth a living organism. They not only appropriate for their own nourishment material necessary to the well-being of the organism in which they are growing, but also form products which are poisonous to the surrounding tissues. Pathogenic or disease-producing bacteria belong to this class.

Are bacteria normally present in the human body?

Yes; especially in the alimentary tract, where they perform the offices of saprophytic bacteria.

What are facultative parasites?

Saprophytic bacteria may occasionally become parasitic and are then called *facultative parasites*. Parasitic bacteria may in turn occur as saprophytes and are called *facultative saprophytes*.

What are necessary factors in the growth and nutrition of bacteria?

A certain amount of heat and moisture is absolutely essential. They require carbon compounds and nitrogen, which must be presented to them in the form of decomposable organic compounds. They develop best where their surroundings are neutral or slightly alkaline in reaction. Some varieties require oxygen, while to others its presence is harmful. Wherever the above conditions are present these organisms will be found.

What is the difference between ærobic and anærobic bacteria?

The former variety can live and grow only in the presence of oxygen, while for the growth and development of the latter class oxygen must be absent. The majority of bacteria may be placed in a so-called facultative class, for they are able to develop whether oxygen is present or not.

What are the products of bacteria?

Ptomaines, pigment of different colors, gases, odors and phosphorescent material.

What are ptomaines?

They are substances of peculiar composition excreted by some forms of bacteria. They are extremely poisonous, as larger animals may be killed by an infinitesimal amount of this toxic material. It is to the action of ptomaines that the injurious effects of the pathogenic bacteria are thought to depend.

What colors may be produced by growing bacteria?

The color-producing bacteria, or, as they are called, the *chromogenic bacteria*, are most of them harmless. The colors produced may be of all shades, black, blue, white, orange, red, yellow, brown, green, etc. Some forms possess the property of producing a phosphorescent glow of considerable distinctness in the dark. Just how these colors and this phosphorescence are produced is not well understood.

What may be said of the gases produced by bacteria?

When a solid culture medium is employed, certain kinds of bacteria growing in its substance possess the power to generate gases which

may be seen as bubbles in the substance in which they are located. Exactly what the nature of these gases is has not been definitely determined.

In connection with this production of gas what other feature is noticeable?

The odors, some of which are intensely penetrating and offensive. They may also be produced without any apparent gas formation. This disagreeable feature of putrefactive change, then, is due to the activity of the bacteria acting as scavengers in their work of tearing apart dead organic materials.

In what way does temperature influence the growth of bacteria?

Most forms, especially of the parasitic varieties, grow best at the temperature of the human body. A great many of the saprophytic forms do not require such a high temperature. If the temperature that is the most favorable to the growth and development of a given bacterium be gradually raised, at first the organism becomes more and more active until finally a point is reached when its activity ceases and it dies. With a gradual reduction of temperature these organisms become less and less active and either lie dormant until the temperature is raised again or they die.

At what extremes of temperature have bacteria been found to grow?

They have been found in sea water and in earth growing at 0° C. the freezing point of water. On the other hand there are forms which require a temperature of 60° C. in order that they may thrive.

At what temperature do the majority of these organisms develop the best?

The purely saprophytic varieties thrive the best at about 27° C. or ordinary summer heat. The parasitic forms are most favorably located for active growth at points ranging from 35° to 40° C.

How are bacteria affected by light?

Ordinary daylight seems to have no particular effect upon them, but if they are exposed to strong sunlight they are liable to lose vitality and finally to be destroyed. Experiments with anthrax spores show that when exposed to strong sunlight for a few hours they lose their power of development.

How are bacteria affected by dryness?

They may die or they may remain for long periods inert. As soon

as moisture is present, however, their activities are resumed. They may have retained life in their original form or in the form of spores, of which more will be said later on.

What is the structure of a bacterium?

It is a single cell, either spherical or rod shaped, and is composed of an albuminous material surrounded by a gelatinous wall or capsule. It has not been definitely determined whether or not it contains a nucleus. The capsule may under certain conditions swell up and cause different individual organisms to stick together, thus forming either a pellicle or thread-like masses.

How do bacteria develop?

From pre-existing cells of the same character and never spontaneously.

CLASSIFICATION, MOVEMENT AND GROWTH OF BACTERIA.

How are bacteria classified?

By their shape.

Name the three great divisions or classes of bacteria.

Micrococci or spherical-shaped forms.
Bacilli or rod-shaped forms.
Spirilli or corkscrew-shaped forms.

Into what classes are the micrococci subdivided?

Staphylococci, growing in irregular masses.
Streptococci, growing in chains like a string of beads.
Diplococci, growing in pairs.
Sarcinæ, growing in fours or multiples of fours.

What are some of the peculiarities of bacilli as regards arrangement and appearance?

Some are long and slender, others are short and thick and may even resemble micrococci. In growing they may develop in irregular masses or in long threads or chains. They may also be slightly curved so that when joined together end to end they form a long spiral.

What may be said of the appearance of the spirilli?

They are shaped like a corkscrew and their spirals may be close or open and few or many in number. Some members of this class have one or more fine filaments or cilia at each end.

What are flagellæ?

They are little thread-like processes or cilia running out from some of the different varieties of bacteria. They have a whiplike motion and are in a constant state of activity. A very few varieties of micrococci have been proved to possess flagellæ.

To what has the term zoöglœa masses been applied?

To any irregular mass of bacteria which is made up of one single kind or colony of a given variety.

Do bacteria possess the power of motion?

The rod-shaped forms or bacilli and the spiral-shaped forms or spirilli possess this power, and in some varieties it has been proved to be due to the action of flagellæ growing from them.

A few varieties of micrococci have the same power of motion, and they also have been shown to have flagellæ. Most varieties of micrococci, however, do not have the power to move from place to place.

What is the "Brownian movement"?

Very often micrococci and also small particles of inorganic matter when suspended in a fluid media between two glasses have an oscillating movement, but it does not serve to propel them about, as they always remain in the same place. This is called the *Brownian movement.*

How do the micrococci grow?

They grow by simple fission, that is, one of the organisms becomes elongated in one direction and appears at first to be slightly indented at the sides. These indentations become deeper and deeper until the organism divides into two. They may stick together as diplococci, and each dividing form four cocci or a tetrad. The process may go on irregularly in all directions and in that manner form irregular masses or staphylococci. When the segmentation continues in one direction, then long chains or streptococci are formed.

How do bacilli grow?

In just the same manner, by fission, but the segmentation always occurs in a direction parallel to the ~~long~~ axis of the organism, and never longitudinally.

How do the spirilli grow?

It is supposed that they grow and increase in the same manner. Their mode of growth however is not well understood.

In what other ways do bacilli grow?

Beside the power of increasing by direct division a large number of varieties possess the power of forming within themselves little bodies called *spores*. These spores might be said to hold the same relation to bacteria as do seeds to more highly organized plants.

How is the spore formed?

The protoplasmic contents of the bacterial cells concentrates at certain points, which appear darker and of a different refracting power than the surrounding material. These points coalesce to form the spore, while the rest of the cell becomes clear and of a light color.

What is the appearance of a spore?

It is oval or round, very highly refractive and has a glistening appearance. At first it may be surrounded by a layer of clear fluid and the outer wall of its parent cell. This wall and the contained fluid finally disappear leaving the spore free.

Why does a bacillus at one time increase by fission and at another by spore formation?

It is thought that when favorably situated the organism increases by fission, and that when altered conditions are present, such as lack of nutriment, unfavorable temperature, etc., that spore formation begins as a means of self-preservation of the species; for the spores are more resistant to outside influences than are the bacilli.

Is there a limit to the kind of spore produced by a given bacillus?

Yes. A bacillus can produce but one kind of spore, and a spore but one kind of bacillus.

To what does the spore owe its power of resisting outside influences?

To a dense, thick wall called the *spore membrane* or *skin* which surrounds it.

How are bacilli produced from spores?

The spore begins to lengthen and its outline becomes rather indistinct. The spore skin seems to swell until finally, as the lengthening process goes on, it becomes ruptured and a young bacillus is set free. This ruptured membrane soon dissolves and disappears.

What is the above variety of sporulation called?

Endosporic sporulation.

What is arthrosporic sporulation?

A given organism takes upon itself the properties of a permanent

cell. It becomes larger and more refractive, and its outer wall becomes firmer and thicker. It may be said, in other words, to have changed directly into a spore. But few observations of this process have been noted, and some authorities doubt the existence of this form of sporulation.

How are spores affected by different conditions of temperature and by dryness?

Some varieties seem to possess the power to retain their vitality for an indefinite period, both when kept dry or when exposed to cold. They retain life at higher temperatures than do the mature bacteria, and when dry are able to withstand a higher degree of temperature than when in a moist condition.

How do bacteria sometimes become self-destructive?

They may die from the action of deleterious material produced by themselves. The mature bacteria are more susceptible to these influences than are the spores. Then, again, they may in a confined space be completely starved out from an exhaustion of the supply of their necessary nutriment. Here, again, the spores may remain in a passive state and resume their activities when more favorable conditions are at hand.

In what part of the bacillus does the spore develop?

It may develop in the centre or at either end. At the point of development there is an enlargement of the bacillus, and when this is situated in the centre of an organism it gives rise to a spindle-shaped body. When formed in the end of an organism it may give rise to a club-shaped body, or, as it has sometimes been compared, to a drumstick-shaped body; hence the name, *drummer bacillus*.

STERILIZATION AND DISINFECTION.

What is sterilization?

It is the process by which *every* micro-organism is destroyed in or upon the material that is to be rendered absolutely sterile and free from bacterial life.

In what ways may this object be attained?

By the application of heat, both in the dry and moist forms. Also, these minute organisms may be destroyed by the application of certain chemical agents which hinder their powers of development.

As preliminary to cultivating bacteria which method is employed, and why?

Sterilization by heat is the only method that is of value in this class of work. For, if chemical agents are used to sterilize and rid different nutrient media of all bacteria, these agents render the media so acted upon useless for the purpose of growing other forms of bacteria.

What form of heat is most applicable to this form of work, and why?

Moist heat in the form of steam is best, for the bacteria and their spores are killed by a less degree of moist than of dry heat.

Why is dry heat not used to any great extent for sterilizing purposes?

A temperature of 150° C. dry heat is necessary to kill absolutely all bacteria and their spores. This high temperature is destructive to most substances that are to be sterilized in bacteriological work, and is therefore only used in sterilizing glass and metal apparatus.

In what way is moist heat used for sterilization?

It may be used under pressure as superheated steam and applied only once, or as live steam, which is of the same temperature as boiling water, and applied discontinuously. Lastly, moist heat may also be applied discontinuously, a little while at a time, at a temperature of 60° C.

When moist heat is used under pressure what temperatures are used?

It is found that temperatures of from 125° to 150° C. are sufficient to kill all forms of bacteria.

What is the principle of discontinuous sterilization?

Most bacteria in their growing forms are killed by a short exposure to moist heat at from 60° to 100° C. The spores are not affected by these temperatures. A few hours after the first exposure some of these spores may develop into growing organisms and then may be killed by a second exposure. This process is kept up a number of days until all the spores have developed and have been killed. Most substances are sterilized by using live steam at a temperature of 100° C. Some kinds of nutrient media are injured by this temperature, therefore a temperature of about 60° C. is employed, and the process is repeated a greater number of times.

What form of apparatus is used for sterilizing materials under pressure?

This apparatus is constructed of metal, and is of sufficient strength

to withstand the pressure of four or five atmospheres. It is fitted with a safety valve, which may be set to blow off at any desired pressure.

Describe the apparatus used in generating dry heat.

It is a simple, double-walled box of sheet iron or copper. Apertures are made for the entrance and exit of air between the double walls, the heat to be utilized entering from the bottom.

What form of apparatus is used for discontinuous sterilization?

This apparatus consists of a chamber fitted with a cover and covered with a non-conducting jacket or an extra wall of metal, so that the steam may not be cooled by contact with outside air. The "Arnold" steam sterilizer is well adapted for this work. The steam is generated in the lower portion of the vessel and rises into the sterilizing chamber through a hollow cylinder. It is so constructed that the water of condensation from the steam is used repeatedly. It therefore requires but little attention.

What is disinfection as differentiated from sterilization?

It is a destruction of bacteria by the chemical action exerted upon them by certain substances which probably enter into combination with the protoplasmic constituents of these organisms.

In order that a disinfectant may act, what is absolutely necessary?

The disinfectant must be brought into direct contact with the organism to be destroyed in order that chemical action may take place. The idea generally prevalent among the laity, that infectious bacteria may be destroyed in apartments by permeating said apartments with disagreeable odors is erroneous.

Name some of the chemical agents that are the most reliable as disinfectants.

Carbolic acid, *chlorine preparations*, *bromine*, *creolin*, *sulphurous acid* and *corrosive sublimate* in solution. This latter chemical is the most powerful of all known chemical disinfectants.

What is an antiseptic?

It is a substance that by its presence inhibits the growth and development of bacteria without necessarily killing them.

What is the most effective of all disinfectants?

Fire. Corrosive sublimate might be placed first on the list of chemical disinfectants, but if much albuminous material were present, its action might be neutralized by combining with the albumen.

PATHOGENESIS AND CULTIVATION OF BACTERIA.

Into what two clinical classes may all bacteria be divided?

Into *pathogenic* or disease-producing organisms, and *non-pathogenic* or those that do not produce disease. This classification is not absolute, however, as an organism that may at one time produce disease, may be so modified by external influences that it loses its pathogenic property and vice versa.

To what is the action of pathogenic bacteria thought to be due?

To the excretion of certain poisonous substances called ptomaines.

How may pathogenic bacteria be deprived of their poisonous qualities?

By successive transplantations in artificial culture media they become less and less virulent until finally they may become entirely innocuous. Also by growing them at high temperatures they quickly lose their poisonous qualities.

In what way may the invasion of pathogenic bacteria be checked in the body?

In blood plasma there is some chemical material, the nature of which is not well understood, that certainly has the power of resisting the attacks of bacteria. Some authors attribute this power to the alkalinity of the blood plasma.

What other theory has been brought forward to explain the resisting powers of the body against these pathogenic invaders?

The phagocytic theory. It is thought that the white cells of the blood are ever ready to attack invading bacteria. That they surround and devour them, or that they become so thickly massed about the invaders as to cut off their supply of nutriment.

Do all forms of bacteria affect the living tissues of the body?

No. Many forms may be found upon the skin and mucous membranes, throughout the alimentary tract and even in open wounds, which seem to give rise to no more disturbance than so much inorganic dust would. These organisms may all be classed as non-pathogenic.

How do pathogenic or disease-producing bacteria affect the living tissues?

The cells of the tissue in which they may be present may become swollen and lose their nuclei, and be changed into granular masses or be totally disintegrated. The intercellular substance may soften and disintegrate. The walls of the bloodvessels in their vicinity may die,

and the bacteria gaining access to the blood current be carried to other ports of the body and grow, producing new foci of necrosis. Some forms seem to incite an inflammatory change with the formation of new tissue.

What factors influence the development of various pathogenic bacteria in the body?

The number of bacteria present; the varying virulence shown by the same organisms at different times; the capacity of resistance of the body-cells.

What is meant by natural immunity against bacterial infection?

Different animals are affected differently by the same organism. As for example, the same micro-organism that will grow and cause disease in one variety of animals may have no effect whatever upon individuals of another kind. The latter then are said to have a natural immunity from that particular organism, and this probably depends upon the peculiar composition of their tissue juices and the behavior of their cells.

What is an acquired immunity?

There are some diseases affecting the human race of which one attack protects the individual from after attacks, thus producing an artificial immunity by natural methods. This is true of the infectious exanthemata. Artificially acquired immunity may be produced against some of the infectious bacteria by inoculations with the attenuated organisms, repeated again and again with stronger and more virulent doses each time.

What are Koch's rules to prove the pathogenesis of a given organism?

It must be proved to be present in all cases of the disease in question. It must be present in no other disease. Then pure cultures must be made of the organism and some animal in which it will grow must be inoculated with this pure culture. The same lesions must be produced in the inoculated animal as those from which the original organism was procured. And finally, the same variety of organism with which the investigation started must be obtained from the inoculated animal.

In what way do bacteria gain access to the body?

Through the skin, the alimentary tract and the respiratory organs.

How are animals inoculated artificially?

Through the capillary circulation of the skin or by hypodermic injections, either subcutaneous, intra-venous, or into some of the larger cavities of the body.

What precautions should be observed in handling materials that are to be examined for bacterial infection?

All fluids should be received in sterilized flasks, and all solids should be wrapped in sterilized cloths that have been moistened with a 1 to 1000 corrosive sublimate solution.

What conditions are necessary for growing bacteria artificially?

A suitable temperature and the proper amount of moisture, together with some organic material containing nitrogen and carbon. As a rule the nutrient mass must be neutral or slightly alkaline in reaction.

What kind of media were first used in cultivating bacteria?

Artificial fluid media were made containing proper nutriment material, as grape sugar, etc. It was seen, however, that bacteria grew better under conditions more closely resembling their natural state. Therefore, infusions of meat were prepared which held sufficient albuminous nutriment material in solution. The trouble with these fluid media is that with them it is very difficult to separate different varieties of bacteria one from the other.

What media are now most often used?

Solid media; either pieces of sterilized potato or those having an animal or vegetable gelatin for a base.

What fluid media are now employed?

Infusion of hay and other vegetable substances are used for growing bacteria which are purely saprophytic. While for those forms that are parasitic beef bouillon is used.

How is the beef bouillon prepared?

Take 500 grams of finely chopped beef, as lean as possible, and add 1 litre of water. Allow it to stand twelve hours. If in summer it must be kept in a refrigerator. Then turn the whole 1500 grams of material into a cheese-cloth strainer and squeeze out just 1000 grams of fluid. To this is added 10 grams of peptone and 5 grams of common table salt. The mixture is then boiled about three quarters of an hour in a water bath. The liquid is usually strongly acid, and is neutralized by the cautious addition of a saturated watery solution of sodium carbonate. Again the fluid is boiled for about an hour and the coagulable

albumunious material is filtered off. It must still be slightly alkaline or neutral. If, after this, the fluid still remains opaque or cloudy, the white of an egg must be added and the whole boiled again for half an hour. The egg albumen coagulation carries off with it the slight turbidity which was present. The clear fluid is again sterilized and poured into sterilized tubes, which are kept carefully plugged with cotton wool.

What is the common way of preparing potato?

The potato is thoroughly scrubbed and the eyes and discolored portions are cut out. It is washed in a 1–1000 solution of corrosive sublimate. After being cooked in a steam sterilizer and cut in halves with a sterilized knife the pieces are placed in a sterilized covered glass dish, having on its bottom a layer of filter paper moistened with a one per cent. solution of corrosive sublimate. This moist paper is for the purpose of keeping the air in the dish in a moist condition.

Potatoes prepared in this way are inoculated by being rubbed with a sterilized platinum wire carrying the bacteria to be grown.

How are potatoes prepared to be used in test-tube cultures?

They are first scrubbed thoroughly and pared. Then with a hollow tin cylinder round plugs of suitable size are cut out of the raw potato. These are divided diagonally and placed in the test tubes with the thick end down. The tube is then plugged with cotton wool and the whole sterilized in a steam sterilizer. The heat of the sterilizing steam cooks the potato at the same time.

In what respect is a solid medium superior to a liquid one?

The colonies of bacteria on solid media develop separately and do not mix as in fluid media.

Describe the solid culture medium devised by Koch.

It is a medium that at one time may be liquefied and at another rendered solid, and in either state it is transparent. Beef bouillon forms the nutrient portion and gelatin the solidifying material.

Give the method of preparing it.

Prepare 1000 grams of meat water as in making beef bouillon, to it add 10 grams of peptone, 5 grams of common table salt and 100 grams of French gelatin. Shake well in a large flask and heat in a water bath for half an hour or until the gelatin is dissolved. It is then neutralized by the careful addition of a solution of carbonate of soda. To this mixture add the white of an egg dissolved in 25 cc. of water,

and heat until the egg albumen has become coagulated. Filter while hot through a filter paper previously moistened with hot water, and preserve in a sterilized flask or sterilized test tubes which are stopped with plugs of cotton wool. When cold the product must be perfectly clear and transparent.

How is nutrient agar agar prepared?

The beef bouillon is prepared in the usual way. To 1000 grams of this, which has been neutralized, add 10 to 15 grams in small pieces of agar agar (a vegetable gelatin). Place the whole in a Florence flask or a porcelain-lined vessel, marking the level at which the mixture stands, and add about 250 cc. of water. Boil the mixture slowly with an occasional stirring for two or three hours. If the level of the fluid falls below the original mark add more water. After boiling the mixture for a sufficient time, put the vessel containing it into a dish of cold water and stir continually. When the temperature has fallen to 68° or 70° C., add the whites of two eggs dissolved in 50 cc. of water and boil slowly for half and hour. Then filter quickly through heavy filter paper previously wet. After filtering, the mixture is poured into sterilized test tubes afterwards plugged with cotton wool. These tubes are placed in an oblique position so that as the mixture solidifies more surface is exposed for purposes of inoculation. Although when hot the filtered product is perfectly clear, on cooling it usually becomes rather opaque.

How are culture tubes prepared with blood serum?

Blood may be procured from small or large animals and received in thoroughly sterilized jars. After standing in a cool place for 24 hours the blood will have formed a clot and the serum will be separated from it. This is removed from the jars and allowed to stand in order that all corpuscular elements of the blood present may settle. The clear serum is drawn off with a pipette and put into sterilized test tubes plugged with cotton wool. The serum is sterilized at a low temperature by the discontinuous method extending over a period of four or five days.

The tubes with their contents are then laid in a desiccator in a slanting position and kept at a constant temperature of from 75° to 78° C. until the serum has solidified. The tops of the cotton plugs are burned off to destroy any mould that may be in them, and covered with rubber tissue to prevent further evaporation. If human blood serum is wanted, the blood may be obtained from a human placenta that has been carefully washed, or from hydrocele or ascitic fluid.

How should test tubes be prepared before the culture medium is put into them?

Whether the tubes are new or have been used it is well to boil them in a solution of common washing soda. After rinsing them they may be washed in water containing one per cent. of commercial hydrochloric acid, and lastly, rinsed in clean *running* water and allowed to drain until perfectly dry. They are then to be stopped with plugs of common cotton wool, non-absorbent. These plugs must be fitted evenly but not too closely. The cotton wool permits the access of air but filters out any organisms that may be floating in it. The tubes are put in a wire basket and sterilized in a dry sterilizer at a temperature of about 150° C. Flasks are prepared in the same way.

Describe the process of filling the tubes.

The nutrient medium in a fluid state is best put in through a small funnel, in order that the mixture does not touch the sides of the tube. They are filled about one-third full and stopped with the cotton-wool plugs, and sterilized in the steam sterilizer for about fifteen minutes each day for three days.

What apparatus is needed in making plate cultures?

Test tubes of nutrient material, an öese, levelling plate and tripod, glass plates and bridges and a culture dish.

What is an öese?

It is a glass rod, in one end of which is fixed a piece of platinum wire. It is used in transferring the material to be studied from one receptacle to another. This platinum wire *must be heated before* and *after* using in order to sterilize it.

What is a levelling plate and tripod?

The levelling plate is made of glass and rests upon a shallow dish filled with water sufficiently to allow only a single large air bubble to be seen under the levelling plate. The dish rests upon the tripod which is fitted with levelling screws in order that the plate may be brought to an exact level. This is determined by the position of the air-bubble.

What is the principle of plate cultures?

The organisms are evenly distributed through the melted culture medium, and poured out upon the glass plates. When the mixture cools the organisms are held so that they are kept separate, and each individual goes on and develops a colony without mingling with any other variety.

How are plate cultures made?

A test tube of nutrient gelatin or agar agar containing the organisms to be studied is melted. The contents of three sterile tubes are also melted and numbered 1, 2, 3. The öese is first thrust into the original tube and then into No. 1; after mixing thoroughly with the öese transfer a drop of the mixture No. 1 to No. 2, mix thoroughly and transfer a drop from No. 2 to No. 3. Each tube of material is now poured upon a separate glass plate previously sterilized and placed upon the leveller. When the nutrient mass has become solid, the plates are placed in a deep glass dish and rest upon glass bridges to keep them separate. They are then covered and left to develop.

How are pure cultures prepared?

When the inoculated plates 1, 2 and 3 as above described have developed, they may be studied with a lens of medium power (one having a focal distance of about one-third of an inch). Colonies of different kinds and appearances will be seen. The colony desired may be fished out with the öese and transferred to a sterilized tube, and the whole process repeated until it is seen that only one kind of colony develops upon the culture plates.

What are Petri culture dishes?

They are small shallow glass dishes having a glass cover. They are about four inches in diameter and are extensively used instead of the plate method just described, as they do away with the leveller and tripod, the glass plates and bridges and the culture dish.

How is the medium prepared in which to cultivate anærobic bacteria.

A plate culture may be made and covered with a sheet of sterilized isinglass. Still further to prevent the entrance of oxygen the edges may be sealed with paraffin. Another method is to introduce into the culture medium a three per cent. to five per cent. solution of formic acid. Still another method is to place the culture tube stopped with the cotton wool into a large tube, in the bottom of which is the following mixture: pyrogallic acid, 1 gram and 10 cc. of solution of caustic potash (5.5 grams of potash to 1 litre of water). The large tube is covered with a rubber cap. The oxygen present is reduced by this mixture and air excluded by the rubber cap. Very good results have been secured by this method.

What other apparatus is needed for the successful cultivation of bacteria?

An incubating oven which is a double-walled metal chamber, having

water between its walls in order that the heat applied may be distributed equally. It is provided with double doors, is covered with felt and has in the top a small aperture in which a thermometer is placed to record the temperature. To heat the chamber a Bunsen burner is most often used; the supply of heat is controlled by one of the many thermo-regulators in use.

In what way are the different varieties of bacteria separated one from the other?

By making plate cultures or Petri-dish cultures as before described.

What points are of value in distinguishing the different varieties?

In a properly prepared plate or dish culture the bacteria will be seen to develop as little spots or foci called *colonies*. Each colony does not come in contact with its neighbor. The points of difference to be observed that are apparent to the naked eye are as follows: Shape of colonies whether regular or irregular, color, and if on nutrient gelatin whether that is liquefied or not. On microscopical examination with a low-power objective (one-third inch) note whether the colonies are smooth or finely or coarsely granular. Also note whether the members of a colony are arranged in radiating lines or concentrically, or in masses resembling cotton wool. These are some of the differences by which one variety of bacteria may be distinguished from another.

What other points are to be considered in taking the life history of a given organism?

Its form must always be the same at the same stage of growth. Its behavior toward different culture media must be the same under the same conditions, and the reactions in different media must follow a fixed rule. It must be observed whether the presence of oxygen is needed or not, whether it possesses the power of motion or not, and whether or not it is pathogenic.

What further steps are necessary to identify an organism?

The examining of cover-glass preparations, stained and unstained. The staining processes will be spoken of later. The unstained specimen may be examined as a hanging drop or as an impression cover-glass preparation.

How are the hanging-drop specimens prepared?

It is necessary to have a glass slide having a shallow concavity ground into one side of it. A drop containing the organisms to be studied is put upon the centre of a cover glass, with a sterilized platinum wire. The cover glass is turned over so that the drop hangs free

in the concavity of the slide. The edges of this concavity may be covered with soft vaseline, so that the cavity is rendered air tight when the cover glass rests upon it.

What are impression cover-glass preparations?

If a clean cover glass is laid upon a given colony and pressed lightly, it will (if lifted straight up) have the colony sticking to it and showing all the peculiarities of arrangement of that colony.

It may be examined in the same manner as a hanging drop, or it may be dried and stained. In a preparation of this kind, the organisms are seen in the positions in which they grew.

EXAMINATION OF THE ATMOSPHERE, SOIL AND WATER.

What is the common method of determining the number and variety of bacteria in the atmosphere?

A plate of nutrient gelatin is exposed to the air to be examined, for a given length of time and then set aside. The organisms that have settled upon it from the air go on and develop, but the results are not accurate. A modification of this plan is to have a cylindrical glass vessel about seven inches long and three inches in diameter. In this is set a shallow dish of nutrient gelatin of a diameter of about two inches. The vessel is plugged with cotton wool and the whole sterilized. To examine a given atmosphere the cotton wool is removed and the dish exposed for a certain number of hours. By this method currents of air are avoided and more accurate results obtained.

Describe Petri's method of making a bacterial analysis of the air.

Small plugs or filters of fine sterilized sand, about one inch long and one-half inch thick, are made and supported in a glass cylinder. It is well to have two such sand-filters in the tube, so that if any bacteria pass through the first they will be caught in the second filter. The air to be examined is drawn through these filters with an air-pump, which, at the same time, measures the amount of air used. The sand is then mixed with a nutrient medium and the bacteria allowed to develop. The filters and glass tube must be thoroughly sterilized before using.

In making investigations of this kind with out-door air, what factors must be considered?

Whether or not the weather is wet or dry (as in wet weather fewer bacteria are floating about). Also, the circulation of the air must be noted as to whether it is quiet or windy.

In examining in-doors air, what must be taken into account?

The length of time the air of the room has been quiet, and the length of time that has elapsed since the room was swept or dust raised in any way.

What average results have been obtained in different places by examinations of this kind?

The number of bacteria present in ten litres (about six hundred cubic inches) of air vary widely according to the conditions present. Examinations have shown the average to be as low as ten and as many as three hundred and seventy-six bacteria present in ten litres of air at different times and places.

In what way are bacteriological examinations of soil made?

The sample of soil may be spread over a plate of nutrient gelatin, or may be mixed directly with the culture medium. It is extremely difficult to get soil from the deeper strata that is uncontaminated with material from strata lying above. However, it has been determined that superficial soil is very rich in bacteria, and that the deeper we go the less abundant they are. In soil below the level of the ground water, it is fair to presume that no bacteria are present, as undisturbed soil forms a very efficient filter.

How are bacteriological examinations of water conducted?

The water to be examined is put into sterilized flasks stopped with cotton wool and covered with a rubber cap. It must be examined as soon as possible after it is procured.

The water is carefully shaken before examination to distribute the organisms present as equally as possible.

A known portion of the water is taken with a *sterilized* pipette and mixed with a sterilized fluid nutrient gelatin. From this a plate or dish culture is made, and calculations made accordingly.

Is the actual number of bacteria present in a given quantity of water of any real significance?

No. A cubic centimetre of water may contain several thousand bacteria and all may be *harmless*. On the other hand, the water examined may be almost free from bacteria and still be very dangerous to life: for the reason that one or more individual organisms present may be pathogenic, *e. g.*, typhoid fever bacilli or cholera vibrios.

As a rule, which contains the greatest number of bacteria, river water or ground water, and why?

River water: for the reason that usually the soil covering the under-

ground water has filtered out the germs that were in the water that trickled through it.

What methods are in use to free drinking water from all bacterial dangers?

Filters of sand, carbon and unglazed porcelain have been used, but they are not absolutely certain in their action.

To be absolutely sure that all bacterial life in water has been destroyed, it must be thoroughly boiled.

STAINING.

What dyes are used in staining bacteria?

Many of the aniline dyes (which are produced from coal tar) have been used, but the ones most commonly depended upon are *fuchsin*, *gentian violet*, *methyl violet*, *methylin blue*, and *Bismarck brown*. Sometimes an *acid fuchsin* is used.

How are these dyes prepared for ordinary work?

Most of them are more soluble in alcohol than in water, Bismarck brown being an exception. Filtered saturated alcoholic solutions of the dyes are made and kept as stock solutions. These stock solutions are never used directly as staining agents, as they give too deep colors. To use them, ordinary clean water or distilled water is colored with the stock solution to be used. This watery solution should be colored so deeply that it is just transparent.

If there seems to be an excess of color, what methods are adopted to obviate this?

The stained specimen may be washed either with water slightly acidulated with a few drops of acetic acid or with strong alcohol, or with Gram's solution.

What is the formula of Gram's solution, and how is it used?

It is a solution of iodine 1 part, potassium iodide 2 parts, distilled water 300 parts. The dye is prepared by coloring a saturated watery solution of aniline oil with the stock solution of gentian violet, added just to the point of saturation. After the specimen is colored with this it is placed in the Gram's solution and then washed with water. The structural elements of the specimen are thus decolorized and the bacteria stand out clear and plain.

What is a mordant?

It is a substance that when added to or used with a dye causes the staining to become fixed in the material so stained.

What mordants are used with the aniline dyes and how are they used?

Aniline oil and also *carbolic acid.* The former is used in a saturated watery solution, to which the stock solution is added almost to the point of saturation. The latter is used in a weak, watery solution.

In what way are the aniline dyes used with caustic potash to give a clear staining?

Methylin blue is the usual dye and may be used according to *Koch's formula*, viz.:

℞ Concentrated alcoholic solution methylin blue ..... 1 cc.
Distilled water..... 200 cc.
1.0 per cent. solution liquor potassa..... 0.2 cc.
℥

or according to *Löffler's formula*, viz.:

℞ Concentrated alcoholic solution of methylin blue..... 30 cc.
Liquor potassa (1 to 10,000 or 0.01 per cent.).... 100 cc.
℥

The latter is the solution usually used.

What is sometimes used as a bleaching or decolorizing agent?

Nitric acid, either in watery or alcoholic solutions.

How are specimens of bacteria prepared upon cover glasses?

If the specimen to be examined is in a fluid state, first put a drop of distilled water on one side of a *clean* cover glass, and with a platinum wire, *just sterilized*, take a drop of the specimen and mix thoroughly with the water. Spread the mixture out into an even, thin layer and dry carefully without exposing it to too much heat. To fix the specimen to the cover glass, pass the glass (held in a pair of forceps) *through* the flame of an alcohol lamp or Bunsen burner. It should be held specimen side up and passed back and forth three times about as fast as the pendulum of an old-fashioned clock swings. If the specimen to be examined is semi-solid, a small piece is pressed into a thin layer between two cover glasses, these are then slid and not pulled apart, with the result of leaving the specimen spread out in a thin smear on each cover glass. This is dried and passed through the flame as above.

How are these cover-glass specimens stained?

They may either be allowed to float, specimen side down, upon the solution of the dye (which solution may be either hot or cold, as

desired). Or a few drops of the dye may be held upon the cover glass itself, and if heat is necessary the solution of dye may be heated in this position by holding it just over a flame. After the dye has acted sufficiently the whole is rinsed in water, and if necessary may be decolorized in any solution desired. The specimen is then dried and mounted, specimen side down, in water, glycerine or Canada balsam, upon a glass slide.

How are tissues prepared for bacteriological examination?

First, the tissue is cut into small cubes which are placed in absolute alcohol for a few days in order that it may become hard and firm enough to cut. It is then fixed upon a cork or block of wood, the best cementing agent being a fairly thick solution of celloidin in equal parts of alcohol and ether. After having been in alcohol a number of hours this cement becomes firm and the specimen is ready to cut. This may be done either with an ordinary razor or with a microtome. The microtome has a movable holder carrying the specimen, and a block moving upon a smooth track, which carries a razor-blade. With this apparatus (a full description of which is out of place here) thinner and more even sections can be cut than with an ordinary razor. With either method both the specimen and razor must be kept constantly wet with alcohol in order that the thin sections of tissue may hold together.

What dyes may be used in staining bacteria in tissue?

The ordinary aniline dyes may be used, or gentian violet according to Gram's method spoken of before, or Löffler's solution of methylin blue. The two latter give the best results.

Give in their proper order the steps for staining bacteria in tissue.

1. The sections which are kept in alcohol are put into distilled water 1 minute.
2. Staining solution, 4 to 5 minutes.
3. Water, 2 to 3 minutes.
4. 0.01 per cent. watery solution of acetic acid, ½ minute.
5. Alcohol for an instant.
6. Absolute alcohol for an instant.
7. Xylol, 2 minutes.
8. Transfer to a slide with a lifter and remove excess of xylol with blotting paper.
9. Mount in xylol balsam.

How is the staining fluid used?

Any one of the staining fluids used for this work just described is placed in a small watch glass. The section is put into the dye and the watch glass, held in a pair of forceps, is held just above a flame until steam and bubbles begin to form. It is then removed a little way. The process is then repeated several successive times, the whole operation taking four or five minutes.

What may be said concerning the use of the alcohol?

It must be used very carefully or else it will take all the color out of the bacteria to be stained. The object of its use is to get all the water out of the section so that the xylol and balsam will make it clear and transparent.

What staining solutions are often used in staining spores?

The Koch-Ehrlich solution of fuchsin and also Ziehl's carbol-fuchsin solution are used to stain the spores directly, while the remaining portion of the bacterium is stained with the ordinary methylin-blue solution.

What is the formula of the Koch-Ehrlich solution and how is it used?

To a saturated watery solution of aniline oil a filtered saturated alcoholic solution of fuchsin is added, almost to the point of saturation. In using this the cover-glass preparation is floated, specimen side down, on its surface in a watch glass. Heat is applied intermittently for four or five minutes, and the specimen is then washed or rinsed in water and decolorized in a mixture of acid hydrochloric 3 cc. and absolute alcohol 100 cc., and again rinsed with water. The above acid mixture removes the red color (given by the fuchsin) from the body of the organism stained, but leaves it in the spores themselves. If now the methylin-blue solution is applied the decolorized portions of the organisms take up this blue color, which gives a marked contrast to the red staining of the spores.

Give the formula of Ziehl's carbol-fuchsin solution and the method of use.

℞ *Fuchsin (in powder)..... 1 gram.
Acid carbolic (crystals)..... 5 grams.
Alcohol..... 10 cc.
Distilled water.....100 cc.
℔

*Grübler's aniline dyes should always be used.

Or it may be prepared by adding to a 5 per cent. watery solution of carbolic acid enough of the saturated alcoholic solution of fuchsin almost to saturate it. Taking some of this solution in a watch glass, proceed as by the previous method. Decolorize with strong alcohol alone, rinse in water, and double stain with the methylin-blue solution.

In staining the flagellæ found on motile bacteria, what precautions should be taken and what solutions should be used?

The cover glasses should be absolutely free from all greasy material, and are best cleaned by warming them in strong sulphuric acid for a time. After this they should be rinsed in water and kept in a mixture of equal parts of alcohol and ammonia. When wanted for use they should be wiped with a cloth that has been freed from all greasy material. As a mordaunt the following solution is used:

℞ Tannic-acid solution (acid, 20 parts; water, 80 parts)..... 10 cc.
Cold saturated solution ferri. sulph..... 5 cc.
Saturated watery or alcoholic solution of fuchsin. 1 cc.

As staining agent use a saturated aniline water solution of fuchsin. Other solutions necessary are a 1 per cent. watery solution of caustic soda and a watery solution of sulphuric acid of such strength that 1 cc. of the acid solution is exactly neutralized by 1 cc. of the soda solution.

Give the process for staining flagellæ.

Several cover glasses are prepared with a drop of clean water upon each. With a platinum wire a drop from the specimen to be examined is thoroughly mixed with the water on the first cover glass. Then a drop of this mixture is mixed with the water on the second cover glass, and so on until five or six dilutions have been made, in order that the individual bacteria may be sufficiently separated. The cover glass to be stained is dried and the specimen fixed upon it in the usual way. Upon this a few drops of the mordaunt solution is put and treated until it steams. It should never be boiled. Next, after rinsing with water, the specimen is stained with the aniline water fuchsin and again rinsed in water, dried and mounted in Canada balsam. The flagellæ of some bacteria require the addition of a few drops of the soda solution, and those of others of one-half a drop or more of the acid solution, in order that they may take the stain.

Give the steps necessary for staining tubercle bacilli.

1. Smear on † cover glasses.

† For purposes of diagnosis always use NEW slides and cover glasses.

2. Dry.
3. Heat.
4. Stain.
5. Rinse in water.
6. Decolorize.
7. Rinse in water.
8. Double stain.
9. Rinse in water.
10. Dry.
11. Mount in Canada balsam.

What may be said concerning the first three steps of this process?

In choosing the material from which to make the smear, cheesy-looking particles, if present, should be taken. The smear is made as before described. The drying may be done by waving the specimen about in the air of the room, or in the heated air over a flame. The third step or *heating* is for the purpose of fixing the smear to the cover glass, and is done by passing it back and forth three times slowly through a flame. Care must be taken not to burn the specimen or cause it to turn brown by too much heat or else it will not take the stain.

What is the most convenient stain to use and how is it used?

The Ziehl carbol-fuchsin is the most convenient. To use it place some of the dye in a shallow dish, float the prepared cover glass, specimen side down, upon it, let it stand five or six hours at the temperature of the room and the staining will be complete. A quicker way is to float the specimen upon some of the dye in a watch glass, and apply just enough heat to cause it to steam, but not boil. This takes about fifteen minutes to stain. Another and still quicker method is to take the cover glass with the specimen side up in a pair of forceps, and pour a few drops of the staining solution upon it. It is now held so that the flame of an alcohol lamp or Bunsen burner just touches the under side of the glass. The solution is allowed just to come to a boil. This may be repeated once or twice, but care must be taken that the staining solution does not dry up. After heating in this way the specimen is thrown into clean water to rinse off the excess of dye.

How is the specimen decolorized?

By dipping into a solution of nitric acid 1 part, water 4 parts, for an instant until all color has disappeared, rinsing at once in water and completing the process in strong alcohol.

What solution is used as a double stain?

Water that has been colored deeply with a filtered saturated alcoholic solution of methylin blue. The cover-glass preparation, after having been decolorized and rinsed in water, is allowed to remain in this solution about one minute. The portions of the specimen that have been decolorized will appear colored blue, while the tubercle bacilli will show up bright red.

THE MICROSCOPE.

What is the ocular or eyepiece?

It is the lens at which the eye is placed in looking at an object.

What is the objective?

It is the lens that comes nearest to the object to be examined.

What is the stage?

It is the platform of the instrument upon which the specimen to be examined rests.

What is the reflector?

It is the mirror placed beneath the stage and is used to throw the light upon the object to be examined.

What is the diaphragm?

It is the aperture in the stage through which light is thrown from the reflector upon the object.

What is the coarse adjustment?

It is either a rack and pinion or a sliding tube arrangement, by which the barrel of the instrument may be raised or lowered quickly in getting the correct focal adjustment.

What is the fine adjustment?

It is a fine micrometer screw that serves to raise or lower the barrel of the microscope very slowly and gradually in order to get the exact focus of the object.

What is an oil immersion objective?

It is sometimes called a homogeneous objective, and is composed of a system of lenses so constructed that it can only be used when there is a drop of oil between it and the object. The oil used is a specially prepared cedar oil. A drop of this is placed on the cover glass over the specimen, and the lens is brought in contact with it. This drop is of the same index of refraction as the glass slide, and therefore no light

coming through the specimen is lost, as none of its rays are deflected before reaching the lens.

What is an Abbé condenser ?

It is a compound illuminating lens mounted underneath the stage of the microscope. It gives a cone of rays that is very broad and short, and that issue from a very wide angle of aperture. In this way shadows that are caused by diffraction are made to disappear in the illuminated picture.

What points are necessary in a good microscope ?

It must magnify sufficiently.

It must give a correct and well-defined image.

Lastly, it must analyze an object into its simplest component parts.

Upon what does the magnifying power of a lens depend ?

Upon its focal distance or distance from the object. The shorter the focal distance the greater the magnifying power.

Upon what does the sharpness of the picture depend ?

Upon the exact spherical and chromatic correction of the objec. glass.

What is the most important factor in determining the defining power of a lens ?

The angle of aperture.

What is the angle of aperture ?

Imagine a line drawn through the front plane of the lens so that it connects the most distant points of its circumference. This is the *diameter*. Also imagine that the object to be observed is a single point. Connecting the ends of the lens' diameter with this object point, the angle formed at the object point is the angle of aperture. The wider the angle of aperture the more rays of light can enter the lens, and the more light the better the definition.

Therefore, a lens of a wide angle of aperture gives better resolving powers than one of a narrow angle.

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